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ENGINEERING:

An Illustrated Weekly Journal.

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See Advertisement page 126. 3157

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See Full Page Advt., page 89, Oct. 15.

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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See Full Page Advertisement, Oct. 15.

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Machine and Engineering WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—RUSSELL & RUSSELL, LTD., Queen's Wharf, Hammersmith.
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See half-page Advert. last week and next week. 3460

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See half-page Advertisement, page 80, Oct. 1.

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TENDERS.

COUNTY BOROUGH OF BURNLEY.

HURSTWOOD RESERVOIR FILTERS.

Tenders are Invited for Com-

plete installation of mechanical pressure filters at Hurstwood Reservoir, Burnley. For particulars, apply to Messrs. James Diggle & Son, Civil Engineers, 14, Brown Street, Manchester. Tenders, endorsed "Hurstwood Filters," to be forwarded to the undersigned not later than the 27th instant.

J. D. Ritchie,
Town Clerk.

Town Clerk's Office, Burnley.
9th October, 1920. K 218

JAMNAGAR-DWARKA RAILWAY COMPANY, LIMITED.

Tenders are Invited for the

supply of about 35 tons of bridge-work, comprising 60 spans of 6 ft. in the clear. Form of Tender, Specification, General Conditions of Contract, and copy of the Contract Drawing may be obtained from the Consulting Engineers, Messrs. Rendel Palmer & Tritton, 12/14, Dartmouth Street, Westminster, S.W. 1, on payment of the sum of 10s. 6d., which will not be returned.

Tenders must be delivered at the above address not later than Noon on Tuesday, 2nd November, 1920. K 366

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. STEEL BOILER PLATES (Flat and Flanged).
2. SCREW SPIKES.
3. STEEL BEARING PLATES.
4. WHEELS AND AXLES (Disc) (360 pairs).

Specifications and Forms of Tender may be obtained at the Company's Offices, 91, York Street, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company Limited, marked:—"Tenders for Steel Boiler Plates," or as the case may be, must be left with the undersigned not later than Two p.m. on Wednesday, the 3rd November, 1920.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1, 2, and 3, and 20s. for each copy of Specification No. 4. Copies of the drawings may be obtained at the office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W. 1.

By Order,
W. B. Reynolds,
for Managing Director.

91, York Street,
Westminster, S.W. 1.
15th October, 1920. K 349

COUNTY BOROUGH OF WALLASEY.

GAS AND WATER DEPARTMENT.

TO ENGINEERS AND CONTRACTORS.

STEEL ROOF FOR BOILER HOUSE.

The Corporation of Wallasey invite

Tenders for the Steel Work of

a ROOF as follows:—
Span, 44 ft.; Length, 44 ft.
Five Trusses with angle iron purlins, gutters, downpipes, etc.

Plans, specification, &c., may be seen, and Forms of Tender obtained on application to the Engineer, Mr. J. H. Crowther, at his Offices, at the Gas Works of the Corporation, Limekiln Lane, Wallasey.

Sealed Tenders on the form provided, addressed to the undersigned, and endorsed "Roof, Gas Extension," to be delivered per post to my office not later than Tuesday, the 16th November, 1920.

Tenders arriving at a later time cannot be considered.

The Contractor will be required to enter into a bond for the due performance of the Contract. The Corporation do not bind themselves to accept the lowest or any Tender.

Dated this 14th day of October, 1920.

H. W. Cook,
Town Clerk.

Town Hall,
Wallasey. K 347

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the "Silent Valley" Storage Reservoir, &c.

The Belfast City and District Water Commissioners are prepared to receive

Tenders from Competent

Contractors for the Construction of the "Silent Valley" Storage Reservoir, &c., in the Mourne Mountains, County Down, having an Earthen Embankment about 1,500 ft. long and 90 ft. high, and a storage capacity of 3,000 million gallons, with an Outlet Tunnel, Waste Channel, and other auxiliary works, also the construction of a temporary Works Railway.

The Contract Drawings and Specification have been prepared by the Commissioners' Chief Engineer, Mr. F. W. M'Cullough, M.Inst.C.E., Water Office, Royal Avenue, Belfast, and may be inspected at his Office on any weekday (except Saturday), between the hours of Ten a.m. and Five p.m.

Duplicate Copies of the Specification and Form of Tender, &c., may be obtained from the undersigned upon payment of the sum of Five Guineas. This sum will only be repaid by the Commissioners after the receipt of a *bona fide* Tender which has not been withdrawn.

On the Tuesday and Friday of each week, commencing with Tuesday, the 28th inst., an Assistant Engineer will meet intending Contractors at the Engineer's Office, at Ten o'clock forenoon, and accompany them to the site of the proposed Works.

Tenders, sealed and endorsed "Tender for Silent Valley Storage Reservoir, &c.," must be delivered by registered post, and addressed to the undersigned, not later than Three p.m. on Wednesday, 3rd November, 1920.

The Commissioners do not bind themselves to accept the lowest or any Tender, nor will they be responsible for any expenses incurred in making out a Tender.

W. I. Quinn,
Secretary,
Water Office, Royal Avenue,
9th September, 1920. Belfast. J 787

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the "Silent Valley" Storage Reservoir, &c.

SCHEDULE OF QUANTITIES.

A Detailed "Schedule of

Quantities" has been prepared by me for the above Extensive Storage Reservoir and other Works in the Mourne Mountains, County of Down. Contractors wishing to Tender for this work will be supplied with Printed Copies of the "Schedule of Quantities" on application and payment to me of the sum of Three Guineas per Copy, which sum will not be repayable.

Acheson Ferguson,
Quantity Surveyor,
Scottish Provident Buildings,
9th September, 1920. Belfast. J 788

APPOINTMENTS OPEN.

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

Applications are Invited for

the following vacancies:—
Lecturer in Mechanical Engineering.
Lecturer in Electrical and Mechanical Engineering.
Salary Scale:—
Grade I. £160—£10—£380.
Grade II. £340—£10—£390—£15—£500.

In fixing initial salary full allowance will be made for years of service in teaching or in industry.

Particulars may be had from the Principal, to whom applications should be sent as early as possible. K 281

UNION OF SOUTH AFRICA.

BREBNER SCHOOL, BLOEMFONTEIN.

Wanted, an Assistant

Master for the Brebner School, Bloemfontein, Orange Free State, South Africa, to commence duties 19th January, 1921. Must be an Associate of the Royal College of Science, London, on the Engineering side, or a Bachelor of Science in Engineering of some recognised University, hold the Board of Education Parchment Certificate, England, or the Privy Council Certificate of Scotland, or a University Diploma in Education, or an equivalent Certificate.

He will be required to teach Mathematics and General Science in the day school and Machine Design, Construction and Drawing and the allied subjects, especially Mechanical Engineering and Mechanics, in the evening classes.

Experience in teaching essential.

Salary £360 per annum rising by annual increments of £20 per annum to £540 per annum, plus War Bonus, which at present for a married man is £132 per annum, plus about £120 per annum for evening class work.

If the successful applicant is prepared to enter into an agreement on his arrival in South Africa, to serve the Administration of the Orange Free State Province for a term of not less than three years, a refund of his passage money to Cape Town at First Class Intermediate (B 3 or B 4) or Second Class Mail (D 1) rate will be granted, on production of the usual receipts. A free railway warrant for First Class Ticket from Cape Town to Bloemfontein and a warrant for 200 lbs. excess luggage will be supplied.

Applications, in duplicate, stating age, academic and professional qualifications and length of teaching experience, with subjects taught, must reach the Secretary, Office of the High Commissioner for the Union of South Africa, 39, Victoria Street, London, S.W. 1, not later than 16th November, 1920. K 304

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.
COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY.

The Council of the College Invites

Applications for the Post of

Professor of Engineering. Salary £1,000 per annum.

Further particulars may be obtained from the undersigned, by whom 100 copies of applications and testimonials must be received on or before Monday, November 1, 1920.

D. J. A. Brown,
Registrar.
October 11th, 1920. K 269

WOLVERHAMPTON EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL SCHOOL.

Required, as Early as Possible

a FULL-TIME LECTURER in MECHANICAL ENGINEERING. University Degree, or its equivalent, and teaching experience essential. Salary £300, rising by annual increments of £25 to a maximum of £400. Application form and further particulars can be obtained upon sending stamped addressed foolscap envelope to the undersigned. Applications must be received by not later than 27th October, 1920.

T. A. Warren,
Director of Education.

Education Offices,
Town Hall,
Wolverhampton. K 227

ROYAL AIR FORCE SCHOOLS OF TECHNICAL TRAINING (BOYS).

Applications are Invited

for a number of VACANCIES in GRADE III. (ASSISTANT MASTERS), on the Civilian Educational Staff of the School for Boy Mechanics at the undermentioned Royal Air Force Station:—

CRANWELL, near SLEAFORD, LINCS.

The subjects of instruction include Practical Mathematics, Applied Mechanics, General Physics, Drawing and English (language, literature, geography, history and civics).

Candidates must possess a University degree or equivalent qualification and will be required to teach either (i) Mathematics and Science, or (ii) English, preferably with Mathematics or Science as a subsidiary subject.

The salary scales, to which the full Civil Service bonus will be added, are as follows:—

	Basic scale.	Approximate rate with current bonus (subject to variation).
Grade I. Headmaster	£450–£20–£550	£757–£904
,, II. Senior Master	£250–£10–£300	£464–£761
	£15–£450	
,, III. Assistant Master	£150–£10–£200	£306–£611
	£15–£350	

In fixing the initial rates of salary in appointments to Grade III., allowance may be made for previous experience of a suitable character up to a maximum of 10 years (10 increments of the scale).

For those who complete three or more years of service there will be a scheme of deferred pay in lieu of pension.

Candidates who are selected to fill these vacancies will be expected to take up the duties of their appointments at the end of the Christmas vacation.

Applications for appointment must be made on the appropriate Form (A.M. 69), which can be obtained from the Secretary, Air Ministry, Kingsway, W.C. 2. K 396

ADMINISTRATIVE COUNTY OF DOWN.

APPOINTMENT OF COUNTY SURVEYOR.

The County Council of the County of Down invites

Applications for the Above-

mentioned APPOINTMENT from Civil Engineers. Each Applicant must satisfy the Local Government Board for Ireland as to his health and character; that upon the 11th November, 1920, next, he is not less than twenty-six nor more than forty-five years of age; that he has been regularly trained as a Civil Engineer; that he is engaged in the practice of his profession, and has for a period of not less than four years had charge of important works in the course of his practice.

Candidates must send in their applications in writing to the Secretary, County Council Offices, Courthouse, Downpatrick, not later than the 11th November, 1920, when a list of the Applicants will be forwarded to the Local Government Board, who after making the necessary enquiries will, if necessary, notify the Civil Service Commissioners of the names of the Candidates eligible for Examination. The result of any examination held will be notified by the Local Government Board to the County Council, who may then proceed to elect as County Surveyor one of the duly qualified Candidates, subject to the approval of the Ministry of Transport.

Applicants who are existing County Surveyors in Ireland, or who have been certified by the Civil Service Commissioners, shall be deemed to be qualified for the position without further examination, but must, however, satisfy the Local Government Board as to experience, age, health, and character. In the case of existing County Surveyors in Ireland the maximum age limit shall 60s, however, apply.

The County Surveyor shall reside at or in the neighbourhood of Downpatrick, an Office being provided at the Courthouse, Downpatrick, for his regular attendance throughout the year, and devote his whole time to the service of the County. He shall discharge the duties of his office in accordance with the Local Government (Ireland) Act, 1898, or any Act now in force, or which may hereafter be passed amending same, the several Orders in Councils or Orders of the Local Government Board thereunder, and the Standing Orders and Resolutions of the County Council of Down.

The salary and emoluments appertaining to the office will be £1,500 per annum, with the use of a motor car.

For all further particulars application should be made to the Secretary, County Council Offices, Courthouse, Downpatrick.

R. J. Dickson,
Secretary to the County Council.
Courthouse,
Downpatrick.
11th October, 1920. K 315

CITY AND GUILDS (ENGINEERING) COLLEGE, SOUTH KENSINGTON.

There is a Vacancy in the

Civil Engineering Department for a DEMONSTRATOR. Total stipend £370 per annum.—Apply, in the first instance, to Professor S. M. Dixon, M.Inst.C.E., City and Guilds (Engineering) College, Exhibition Road, London, S.W. 7. K 346

Assistant Machine Shop

MANAGER REQUIRED for large Engineering works. Must have first-class experience in all latest machine tools and up-to-date methods for obtaining output. Plant to be controlled includes large variety and a big range in sizes of machine tools. Permanent post for progressive man.—Address, stating age, salary expected, also experience and qualifications, K 346, Offices of Engineering.

Mill Manager.—Wanted, by

an Important Firm of Steel Manufacturers in the Midlands possessing several large rolling mills, a MILL MANAGER, with a thorough knowledge of the production of Blooms, Billets, Sheet Bars, Rounds and sections.—Address, in confidence, stating age, experience and salary required, K 331, Offices of Engineering.

Wanted, Manager, London

Office of North England Manufacturing Engineers; knowledge handling of bulk materials desirable. State selling experience, references, age and salary.—Address, K 345, Offices of Engineering.

Manager (Engineering.)—

OUTSIDE MANAGER WANTED for large Ship Repairing and Engineering Works, Liverpool District. Must have good general experience.—Address, giving full particulars, age, experience and salary required, K 385, Offices of Engineering.

Assistant Manager Wanted

for Outside Department of Clyde Marine Engineering Firm. Applicant must have the following experience, Workshop, Drawing Office, fitting out of machinery on board ship in the Harbour, or carrying out repair work. Preference given to one having Board of Trade Certificate. Apply stating experience and salary expected.—Address, "MARINE," Wm. Porteous & Co., Advertising Agents, Glasgow. K 306

Wanted, for India, Com-

petent SALESMAN, with ability to conduct commercial correspondence, having a thorough general acquaintance with all kinds of Engineering Machine Tools, Woodworking Machinery, &c. Able to give demonstrations. Age under 30. Single.—Address, K 100, Offices of Engineering.

Costs Accountant, Wanted for

important Engineering Works in Manchester District. Must have had good experience in similar position and be able to act without supervision. Good organising ability essential. Full particulars and salary required in first instance.—Address, K 397, Offices of Engineering.

Estimating and Rate Fixing.

CHIEF ASSISTANT REQUIRED by Midland Engineers producing Small and Machine Tools, &c. Shop training, with Drawing Office experience, good education and knowledge of mechanics and mathematics, combined with good commercial experience essential.

Address, giving full particulars of experience, age and salary required, K 405, Offices of Engineering.

Civil Engineers

REQUIRED by the Government of Ceylon for appointment as Irrigation Engineers for three years' service in the first instance. Salary £450 per annum with a temporary war allowance of 33⅓ per cent. Free passages provided. Candidates, not over 35 years of age, who must have passed the A.M.Inst.C.E. or an equivalent examination, and who have a thorough knowledge of Survey, levelling, earthwork and the principles of road making, waterworks and building construction, preferably with actual experience in the design and construction of irrigation projects, should apply at once, in writing, giving age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1, and quoting M/Ceylon 10348. K 400

Civil Engineers Re-

QUIRED by the Government of Ceylon, for three years' service as District Engineers in the PUBLIC WORKS DEPARTMENT with possible extension. Salary £450 per annum with a temporary war bonus of 33⅓ per cent. Free passages provided. Candidates, preferably single and between the ages of 25 and 35, should have passed the A.M.Inst.C.E. Examination, or the qualifying examination of the Municipal and County Engineers, or the examination for Professional Associateship of the Surveyors' Institution (Building Section) and possess practical experience on works. They should be competent in engineering, surveying and levelling. Apply at once, in writing, giving age and brief details of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Ceylon 10336. Applicants must have served in some branch of H.M. Forces during the late War unless satisfactory reasons for not having done so can be furnished. K 402

SINGAPORE—STRAITS SETTLEMENT.

ELECTRICIAN-ENGINEER FOR POWER HOUSE.

Wanted, for a Portland

Cement Works in Singapore, recently completed, an Experienced ELECTRICIAN-ENGINEER. Salary £650–£700 per annum, with free house at site and participation in bonus. Three years' agreement; excellent prospects. Capital cost of Works, £350,000. Power-house plant consists of four return-tube boilers, one 300 Kw. and one 200 Kw. "Belliss" A.C. 3-phase sets, 3200 volts, transformed to 440 and 220 volts. Electric light. Further plant to be installed: 1500 Kw. Steam Turbo-Generator.

Applications, stating age, married or single, salary required, training and experience in detail, with dates, and copies of not more than six testimonials or suitable references, to be lodged with C. C. Lindsay & Phirce, MM.Inst.C.E., 180, Hope Street, Glasgow, on or before 26th October. K 398

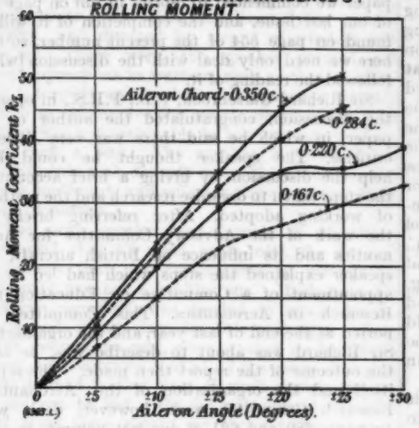
THE DESIGN OF AEROPLANE CONTROL SURFACES WITH SPECIAL REFERENCES TO WING AILERONS.

By H. B. Irving, B.Sc., A.F.R.Ae.S., of the National Physical Laboratory.

(*Concluded from page* 494.)

Variation of Aileron Chord.—The range of aileron chord covered in the experiments was from 0·167 to 0·350 of the wing chord. The increase in rolling moment as the chord increases is illustrated by

Fig. 14. ROLLING MOMENT & HINGE MOMENT FOR AILERONS OF VARIOUS CHORDS. ALL FOUR AILERONS. INCIDENCE 8°. ROLLING MOMENT.



ROLLING MOMENT AND HINGE MOMENT FOR AILERONS OF VARIOUS CHORDS. ALL FOUR AILERONS, INCIDENCE 8°.

Fig. 17. HINGE MOMENT PER UNIT AILERON AREA.

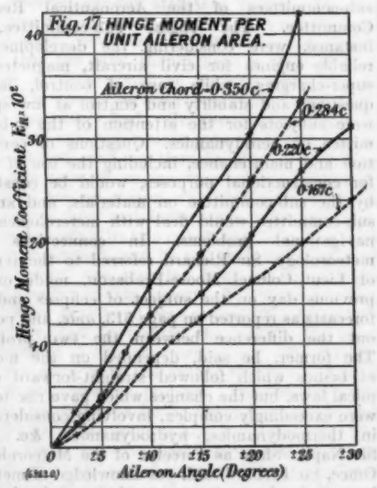


Fig. 14. That rolling moment does not, however, increase in proportion to chord length is shown by Fig. 15, from which the rolling moment per unit aileron area is seen to be less the greater the aileron chord. With hinge moment the reverse is the case; it increases very rapidly with chord (Fig. 16) and hinge moment per unit aileron area also increases with chord (Fig. 17). In consequence there is a rapid reduction in the ratio of rolling moment to hinge moment as the aileron chord is increased; this is exemplified by Fig. 18.

Considering now the efficiencies of ailerons of different chords, it is seen that, as far as L/H ratio is concerned, the smaller the ailerons the more efficient they are. But, from the general considerations on gearing given previously, it was seen that, apart from L/H ratio, the larger the ailerons, or the more rolling moment they produce for a given setting, the more efficient they are. These opposing tendencies result in maximum efficiency for ailerons whose chord is about 0·25 of the wing chord. The way in which efficiency varies with chord is shown by Fig. 13, page 494 *ante*, which was obtained from a comparison made in a similar way to that adopted for comparing ailerons of different spans. According to this figure the efficiency is a maximum for an aileron chord of about 0·21 C; but this conclusion was modified slightly by making comparisons for different values of the maximum rolling moment. So that, speaking generally, it is only possible to say that the best aileron chord is between 0·21 C and 0·28 C, or roughly, about one-quarter of the wing chord.

In qualitative confirmation of this result it may be mentioned that full-scale experiments made at

Fig. 15. ROLLING MOMENT PER UNIT AILERON AREA.

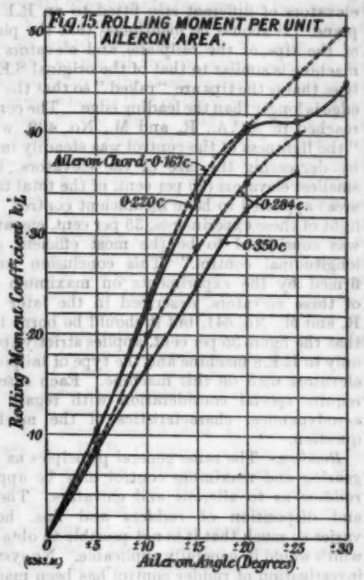
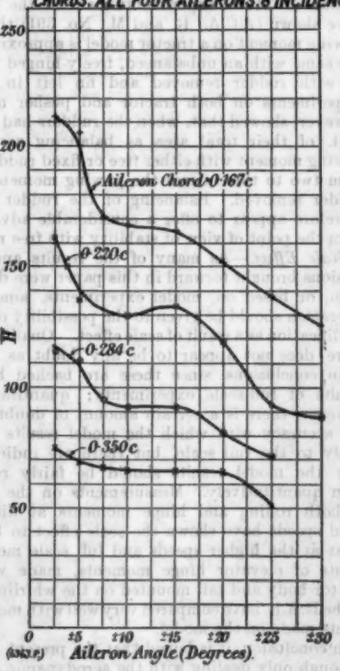


Fig. 18. RATIO OF ROLLING MOMENT (L) TO HINGE MOMENT (H) FOR AILERONS OF VARIOUS CHORDS. ALL FOUR AILERONS. 8° INCIDENCE.



the R.A.E. and described in A.C.A., R. and M., No. 413, have shown the efficiency of control to be noticeably improved by reducing the aileron chord from 0·36 to 0·24 of the wing chord. This chord is rather smaller than the general run of chords adopted in machines of the last few years, with certain exceptions, which are perhaps mostly to be found in German practice, where there are several instances of machines having ailerons of very small chord. An interesting example of the employment of ailerons of very small chord combined with very long span is to be found in the Curtiss 18 B. biplane described in *Flight* of July 10, 1919. In this machine, which has ailerons on the lower wing only, the chord of the ailerons is 0·22 C and the span 3·36 C, or 0·72 of the semi-span. A steel tube forms the leading edge of the aileron and is continued along the wing to the body where the control levers are connected directly to the tube.

It is now proposed briefly to consider some special experiments which were made on unbalanced ailerons. These included tests on ailerons of the

ROLLING MOMENT AND HINGE MOMENT FOR AILERONS OF VARIOUS CHORDS. ALL FOUR AILERONS, INCIDENCE 8°.

Fig. 16. HINGE MOMENT.

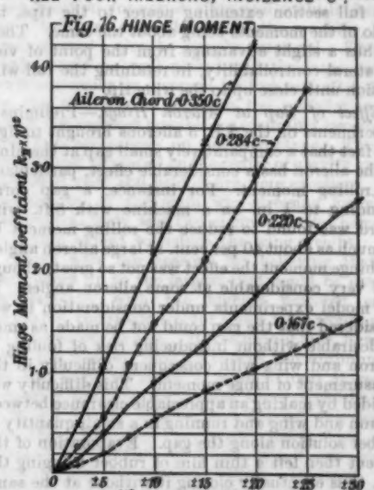
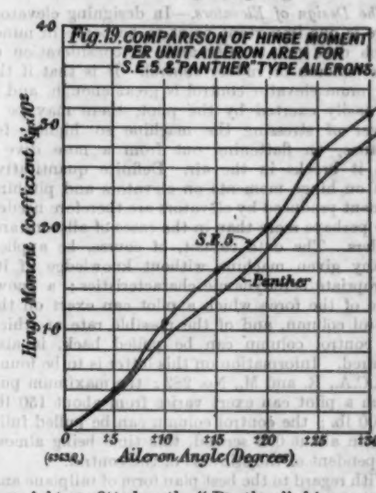


Fig. 19. COMPARISON OF HINGE MOMENT PER UNIT AILERON AREA FOR S.E.5. & "PANTHER" TYPE AILERONS.



special type fitted on the "Panther" ship aeroplane, tests on the effect of variation of taper of wing tip on aileron performance and tests to find the effect of a gap at the hinge between aileron and wing.

Ailerons of "Panther" Type.—The ailerons fitted to the "Panther" ship aeroplane, which is a small single-seater biplane, are of the ordinary unbalanced type except that they do not extend quite up to the wing tips, fixed portions of which extend beyond the ailerons. The control given by these ailerons in practice is stated to be quite satisfactory. As the plan form of the wing tips of the "Panther" aeroplane is almost identical with that of S.E.5 wing tips, these latter were adapted (see Fig. 1) and used for tests on the "Panther" type of aileron. What is perhaps the most interesting result of the tests is exhibited by Fig. 19. Here hinge moment per unit aileron area is plotted for both S.E.5 and "Panther" type ailerons. The curves show the values for the S.E.5 ailerons to be about 20 per cent. higher than for the "Panther" type, thus demonstrating that it is the portion at the outer end of the S.E.5 ailerons which is

responsible for the relatively heavy lateral control experienced with this type of aileron.

Effect of Variation in Taper of Wing Tips.—The taper of the "square" wing tips of Fig. 1 (page 462 *ante*) began at three-quarters of the chord length from the wing tip. It was thought that it would be useful to find what difference in performance of the ailerons would follow the carrying of the full section nearer to the tip. Tests were, therefore, made on ailerons fitted to wings whose taper did not begin until one-quarter of the chord length from the tip, these tips being designed for a series of experiments, on the balancing of ailerons. The nature of the results was very similar for the two sets of ailerons. Both rolling moment and hinge moment showed an increase of, roughly, 5 per cent. for the wings with the full section extending nearer to the tips, the ratio of the moments being about the same. There is thus a slight advantage from the point of view of lateral controllability, in retaining the full-wing section until close up to the wing tip.

Effect of Gap at Aileron Hinge.—Preliminary experiments on the S.E. 5 ailerons brought to light the fact that a comparatively small gap at the hinge of the aileron has a considerable effect, particularly on rolling moment. For instance, a gap corresponding to $\frac{1}{4}$ in. on a machine with 5-ft. wing chord was found to reduce the rolling moment by as much as about 40 per cent. at large aileron angles. On hinge moment the effect was not so great, though still very considerable at some aileron angles. In the model experiments under consideration it was considered that the gap could not be made as small as desirable without introducing risk of fouling of aileron and wing with consequent difficulty in the measurement of hinge moment. This difficulty was avoided by making an appreciable clearance between aileron and wing and running in a small quantity of rubber solution along the gap. Evaporation of the solvent then left a thin film of rubber bridging the gap, thus effectually closing it without at the same time interfering with measurement of hinge moment.

The Design of Elevators.—In designing elevators there is one important point to be borne in mind, which does not usually arise in consideration of either aileron or rudder control. It is that if the maximum elevator control is great enough, and is too easily exerted by the pilot, there may be a danger of stressing the machine so highly—for instance, on flattening out from a nose dive—that it breaks in the air. Definite quantitative data on hinge moments on elevators and pitching moment produced by elevators are therefore needed here perhaps more than in the cases of ailerons and rudders. The data cannot, of course, be applied to any given machine without knowledge of its appropriate aerodynamic characteristics; a knowledge of the force which a pilot can exert on the control column, and of the possible rate at which the control column can be pulled back, is also required. Information on this latter is to be found in A.C.A., R. and M., No. 282; the maximum pull which a pilot can exert varies from about 150 lb. to 200 lb.; the control column can be pulled fully back in about 0·2 second, this time being almost independent of the stiffness of the control.

With regard to the best plan form of tailplane and elevator, as has already been mentioned, a similar conclusion to that reached from model experiments on ailerons has been arrived at from full-scale experiments. There is a considerable amount of model and full-scale data on the control exerted by elevators of various designs, so that, in most cases in practice, a fair estimate may be arrived at as to the magnitudes of the moments involved in movement of the elevators. No systematic extensive series of model experiments on the effect of variation of elevator chord has, however, yet been made. A short series of experiments on a model of B.E.2c body and tailplane with elevators has been made (A.C.A., R. and M., No. 254), but the range of elevator chord was only from 0·6 to 0·4 of the tailplane chord. Tests of elevators of three different chord lengths 0·6, 0·5 and 0·4, showed that the pitching moments given by these were not very different in magnitude, while hinge moment decreased rapidly with chord. Comparison of the efficiencies of the three elevators showed that the maximum efficiency would not occur until a chord considerably smaller than the smallest tested had been reached. For the present, it would appear, therefore, that the best assumption to make is that the best chord is about the same for elevators as for ailerons—that is, for a tail of rectangular plan form. The adoption of a small chord will make it necessary to inquire as to whether the maximum control may be made sufficiently great. On this point, as well as on the question of variation of efficiency with chord, there is information from full-scale experiments. It is contained in A.C.A., R. and M., Nos. 409 and 641, by the R.A.E., which reports give an account and analysis of experiments on four elevators of different size fitted to an R.E.8 aeroplane. It should be mentioned that the plan form of the tips of the tailplane and elevators of this machine is similar to that of the original S.E.5 wing tips, that is the tips are "raked" so that the trailing edge is longer than the leading edge. The conclusion reached in A.C.A., R. and M., No. 409, was that "the lightness of the control was steadily improved by decreasing the size of the elevators, but the smallest elevators (30 per cent. of the total tailplane area) appeared to have insufficient control. In the light of these experiments, 35 per cent. elevator area was considered to be the most efficient size for longitudinal control." This conclusion was confirmed by the experiments on maximum control of these elevators, described in the later A.C.A., R. and M., No. 641, but it should be borne in mind that the figure 35 per cent. applies strictly speaking, only to R.E.8 machine and the type of tailplane and elevators used on this machine. Each case would require special consideration with regard to the aerodynamical characteristics of the machine in question.

Rudders.—The same general principles as regards gearing and maximum control may be applied to rudders as to ailerons and elevators. The shape and disposition of rudders and fins, however, varies so much that it is not possible to obtain data which would be generally applicable. No systematic investigation of rudder control has been made, and for the present the designer has to rely on miscellaneous experiments and current practice for guidance. Model experiments made at the R.A.E. have shown (A.C.A., R. and M., No. 391) that the yawing moment on a tractor model is approximately the same with an unbalanced, freely-hinged rudder as with rudder removed and fin left in place. Experiments on both tractor and pusher models, however, showed that, when the rudders had 12 per cent. of their total area as balancing area, the yawing moment with either free or fixed rudder was from two to three times the yawing moment with rudder removed. Balancing of the rudder would therefore appear to offer a considerable advantage from the point of view of stability with free rudder.

Scale Effect.—As many of the results and conclusions brought forward in this paper were derived from, or based on, model experiments, some consideration should be given to the possibility of their modification as a result of scale effect. Qualitatively there does not appear to be any doubt as to the main conclusions, since these are backed by the results of full-scale experiments; quantitatively, however, there is a certain amount of doubt as to the accuracy with which the model results would apply to the full scale, but there are indications that the model results should be fairly reliable even quantitatively. Measurements on the model of both rolling and hinge moments at different wind speeds have shown the scale effect to be not great at the higher speeds and full scale measurements of elevator hinge moments, made with a tractor body and tail mounted on the whirling arm at the R.A.E. have compared very well with measurements made on the model.

In conclusion, it is hoped that the present paper, although only dealing with the aerodynamic aspect of the design of control surfaces, and more particularly of unbalanced ailerons, will nevertheless help to place this branch of aeroplane design on a more rational basis than has hitherto obtained.

British Production of Pig Iron and Steel.—The production of pig iron in September amounted to 741,000 tons; the production of steel ingots and castings in the same month was 883,900 tons. This last figure for steel production is the highest attained since the Armistice.

THE AIR CONFERENCE.

(*Concluded from page* 515.)

Aircraft Research and Contemplated Developments.

On Wednesday morning, the 13th instant, the chair was taken by Lord Weir of Eastwood, who, in calling on Air Vice-Marshal Sir E. L. Ellington, K.C.B., Director General of Supply and Research, to read his paper entitled "The Present Position of Aircraft Research and Contemplated Developments," expressed the hope that the day's deliberations on the technical side of aviation would be as successful as those of the previous day had been on the commercial side of the subject. The paper we commenced to reprint in full on page 504 of our last issue, and the completion of it will be found on page 554 of the present number, so that here we need only deal with the discussion which followed the reading of it.

Sir Richard Glazebrook, C.B., F.R.S., in opening the discussion, congratulated the author on his paper, in which he said there was very little to criticise. The speaker thought he could best help the discussion by giving a brief account of the steps taken to organise research and the methods of working adopted. After referring briefly to the work of the Advisory Committee for Aeronautics and its influence on British aircraft, the speaker explained the steps which had led to the appointment of a Committee on Education and Research in Aeronautics. This Committee reported at the end of last year, and the organisation Sir Richard was about to describe was, he said, the outcome of the report then made. The report itself and the organisation of the Aeronautical Research Committee were, however, dealt with on pages 289 and 621 of our last volume, so that it is unnecessary to repeat the matter here. Many of the points raised in the paper, Sir Richard continued, were now being considered by the various sub-committees of the Aeronautical Research Committee. The engine sub-committee, for instance, were considering the development of reliable engines for civil aircraft, magnetos, and super-charging, while ease of control, landing questions and stability and control at low speeds, were subjects for the attention of the sub-committee on aerodynamics. Questions of construction and maintenance, including the use of metal for constructional purposes, would be considered by the sub-committee on materials, and another sub-committee would deal with meterological and navigational problems. In connections with meteorology, Sir Richard referred to the remarks of Lieut.-Colonel Moore-Brabazon, made on the previous day on the subject of eclipses and rain forecasts as reported on page 513, *ante*, and pointed out the difference between the two problems. The former, he said, depended on the motions of bodies which followed straight-forward dynamical laws, but the changes which gave rise to rain were exceedingly complex, involving considerations in thermodynamics, hydrodynamics, &c. With Sir Napier Shaw as Director of the Meteorological Office, Sir Richard said, our knowledge of meteorology had advanced enormously, and he had no doubt that it would continue to advance under his successor, Dr. G. C. Simpson, who would require the assistance of all sections of the Air Force. Referring to the staff and equipment available for aeronautical investigations, Sir Richard said that the Royal Aircraft Establishment at Farnborough was admirably equipped to deal with all the problems referred to in the paper, while the National Physical Laboratory was well adapted for investigating problems of a more theoretical nature, and in concluding his remarks, Sir Richard expressed the hope that zeal for economy would not outstrip the need for efficiency, and urged the necessity for maintaining adequate staffs in the Government research departments as well as in the designing departments of private firms.

Lieut.-Colonel Moore-Brabazon, who followed, said he fully appreciated the difficulties of meteorology, and had no doubt that if such men as Sir Richard Glazebrook studied the problems, we should be nearer to their solution. With regard to the paper he wished to refer to two sins of omission.

The first of these was the omission of any reference to aerial photography. But for aerial photography the speaker considered that the war might still be in progress, since trench warfare had resulted in a stalemate. During the war, photography had developed enormously so that, towards the end, about 2,000,000 prints a month were produced. It would be a pity not to continue studying the subject, as it was a difficult problem to take photographs at a speed of 160 miles per hour within a few feet of a 300 h.p. engine. The results obtained were good, but by no means perfect, and the speaker thought that continued investigations would bring perfection nearer. The other matter not dealt with in the paper was one which had been kept very secret during the war, viz., experiments made with aeroplanes flying without a pilot, and directed by means of wireless telegraphy. There were, the speaker pointed out, many operations in warfare, such as that of carrying a torpedo and exploding it against a warship, which would involve the certain death of the pilot, and it was not reasonable to ask any man to carry out such a task. The speaker inquired if the experiments with aircraft directed by wireless were being continued, and whether there was any likelihood of success.

The next speaker was Captain F. M. Green, who said that all must agree with the author's statement that the development of aircraft for war only was not a healthy one. Much time, the speaker remarked, was needed to reconsider designs and collect data for future designs. Many good designs, he said, were spoiled by bad detail work, and he hoped that all of the many draughtsmen trained in this class of work during the war would not be lost. He did not suggest subsidies, but some steps should, he thought, be taken to keep design staffs together. One point to which reference had been omitted from the paper was that of the pilot's view, and although this matter had received careful attention during the war, there was a tendency to overlook it in new designs. He thought, however, that it was necessary to insist that the pilot should have a clear view in the air as that would be an important help in navigating under adverse conditions when visibility was rather bad. He also noticed from the paper that the swash-plate type of engine was to be developed, and he thought that expectations from this type of engine were rather optimistic. He could see no reason why this type of engine should be lighter and better than the usual type. The steam engine, he also noted, was to be developed for use on aircraft, and he was surprised that good fuel economy was expected from it; he thought it likely to fail in this respect. Metal construction, the speaker considered, was essential for aircraft of the future, and he blamed the war for the great development of timber construction. He did not, however, agree with the author that the unbraced wing would solve the problem. In such wings the bracing, he said, was inside instead of outside, and was of vital importance although covered up. Unbraced wings, however, had other advantages, and their development was of importance. With regard to the use of wing flaps on the trailing edge to increase the lift coefficient, he pointed out that a machine had been made and tested at the Royal Aircraft Establishment in 1914. The results of the trials were available, but the speaker's impression was that the advantages gained were not worth the increased complication. In conclusion, he wished to say that the aircraft industry was greatly indebted to the scientific and practical branches of the Air Ministry at the Royal Aircraft Establishment, the National Physical Laboratory, and Martlesham for the valuable data obtained for design. From Martlesham, in particular, the industry was able to obtain the accurate figures essential to progress in a very short time.

Mr. A. E. L. Chorlton spoke on the subject of engine design, and pointed out that considerable advance might be made if designers were set some more definite problem. On the one hand, there was, he said, a desire for a reliable and economical engine, and one in which weight was not vital, while on the other hand a light engine was demanded. The recent trials at Martlesham, he said, had really resolved themselves into engine trials, and it was noticeable that the lightest engine obtained the prize. If the limit of weight could be defined, designers, he said, would have something to go upon, and at a Conference such as they were now attending, it should be possible to set out requirements in detail. In the matter of fuel consumption, the speaker continued, there was little doubt that heavier engines were more economical, which was largely due to the fact that higher compression could be used. Such economy would, however, only be of advantage in long journeys, as in short journeys, the additional engine weight would over-balance the smaller fuel requirements. With regard to the resuscitation of the steam engine, he asked where would be the gain. They were bound to use oil fuel in either case, and the thermal efficiency of the steam turbine was not above 15 per cent., whereas that of the internal combustion engine was 30 per cent.; that, he said, was the basic difficulty. Supercharging and forced induction, the speaker continued, had received much attention as a means of obtaining increased power and further economy. An engine for commercial aviation, he said, should be capable of giving a 25 per cent. increase of power for five minutes at a time to enable the machine to get off the ground easily, while in the air the power could be reduced to 75 per cent. of the normal, or less. In conclusion, the speaker expressed the view that development of aircraft would not be hampered by the lack of high-power engines, and stated that if engines of 5,000 h.p. were required in four or five years' time they would be available as soon as the machines were.

The only other contribution to the discussion was from Mr. E. R. Calthrop, who spoke on the subject of parachutes. He stated that in the rules first issued by the Air Ministry in connection with the recent trials of aircraft there were certain clauses relating to the provision of parachutes for life saving. These clauses were, however, omitted from the rules issued later, and no parachutes were carried on any of the machines entered. He enquired the reason for the omission and expressed the view that some explanation should be given, since its effect had been to cause the impression that the Air Ministry was opposed to the use of parachutes. The impression was, he thought, without foundation, but it was widely prevalent. Mr. Calthrop was unable to conclude his remarks before it became necessary for the Chairman to adjourn the meeting for the members of the Conference to visit the London Terminal Aerodrome at Croydon.

Croydon, it should be explained, is a State-owned Customs aerodrome under the direction of the Controller General of Civil Aviation, and is the London Continental air terminus. It is equipped with hangars, workshops, technical stores, petrol stores, &c., and certain of the buildings are rented by companies operating regular services to Paris and elsewhere. There is also a hotel and garage, a Customs office and a traffic office. At present paraffin flares, arranged in the form of a letter L with the vertical stroke placed in the direction from which the wind is blowing, are lit each night, and kept burning for 1½ hours to facilitate the landing of aircraft after dark, but electric landing lights are now being installed, and these will supersede the paraffin flares. An aerial lighthouse having a range of 30 miles is provided, and three searchlight projectors are installed, one at each corner of the aerodrome. The searchlights are used alternatively, to throw fixed beams vertically upwards to assist aircraft to locate the aerodrome at night, to illuminate machines which may have broken down on the aerodrome, and to assist aircraft to land in the event of a failure of the electric landing lights above referred to. Wireless telegraphic apparatus is installed for communication with the aerodromes at Paris, Brussels, and Amsterdam, and with the intermediate stations, and a wireless telephone enables direct communication to be maintained with machines in flight. Wireless direction-finding apparatus is also used.

The Technical Aspects of Aviation.

After the return from Croydon a session was held at 5 p.m., at which Captain F. S. Barnwell read a paper entitled, "The Technical Aspects of Service and Civil Aviation." The paper was suggestive rather than constructive, and consisted in the main of an enumeration of various points in aeroplane design to which experiment and study might well be devoted. Captain Barnwell began by pointing out that by the end of the war all types had evolved to the single engine tractor biplane, except for machines too large to be flown by the highest-powered engines available, for which the twin-engine tractor screw fuselage biplane had become fairly well established. The single engine tractor machine had good reasons for its predominance. The air screw was in the best position for ground clearance, efficiency and safety, while the engine was in the best position for accessibility and could be isolated by a bulkhead from the rest of the machine. The cooling could also be simply arranged. The fuel tanks could be well placed and the large weights were conveniently disposed for fore and aft balance. In the twin-engine machine the installation was about the simplest possible for mounting two engines and two air screws on one aeroplane. The fuel tanks could be placed on the centre of gravity and the all-round view and field of fire were excellent. The splitting-up of the main wire-stressing loads into one central body and two engine nacelles helped to a certain extent to reduce the wing weight.

There were fair reasons for believing that for aeroplanes up to the largest that could be powered satisfactorily with the highest powered engine available, the single-tractor screw type would prove as satisfactory as any. It was improbable, however, that the biplane wing form was the optimum for all sizes and purposes. Up to a limit it seemed probable that the monoplane form might be best, followed by the biplane and beyond this by the triplane. The problem of optimum wing form seemed well suited for wind tunnel and mathematical investigations. Captain Barnwell then went on to suggest a complete line of experimental work on this point, followed by mathematical working out of weights of wing structures for a series of sizes of different forms. He also proposed a series of wind tunnel investigations on complete models with air-screws running, the drag forces being analysed. On each model tested systematic variations of body shape, due to variations of cooling systems, &c., would be tried out. Weights should be tabulated and analysed while considerable more investigation was also needed on the applied forces and the load factors requisite for every part of the structure.

The paper then went on to deal with some of the separate elements of aeroplanes. Air screws, for instance, should be investigated from the point of view of improvement in reliability and durability. The metal air screw should also be investigated. In the matter of engines an attempt should be made at using a heavier fuel than petrol. The air-cooled engine should also be developed and consideration given to the two-stroke engine in view of its smaller number of working parts. Efficient and reliable reduction gearing between crankshaft and airscrew was also practically essential for all but extremely fast and highly-powered machines. The question of wing form had already been referred to, but it also appeared desirable to have a systematic investigation for optimum tip form. Cantilever wings would appear worth investigation, particularly in conjunction with metal spars, and research was wanted on the durability of wooden wings as against metal wings, taking cost into account. Comparative tests were highly desirable on metal monococque bodies, plywood monococque bodies, girder bodies of metal and girder bodies with wood longitudinals. Research was also wanted on body covering materials and their method of attachment. Much work was requiring to be done on under carriages, while the whole question of the electrical, or hydraulic, operation of controls would appear a suitable subject for experiment.

After the reading of the paper Lord Weir, the chairman, congratulated the author, but before the discussion was taken two resolutions were unanimously passed. The first recorded the opinion of the conference that the recommendations of the Advisory Committee on Civil Aviation should be carried out, and the second that the existing research staffs of the Air Ministry and the National

Physical Laboratory should be maintained at full strength.

Air Commodore H. R. M. Brooke-Popham opened the discussion. He said that the longer one was connected with aviation the more he realised the depth of his ignorance. There was no need to be despondent, however, and it was helpful to think of the work done by the pioneers of ten years ago and the conditions under which that work was done. Progress was so rapid now that one could never afford to rest on the strength of what had been done. We had done well, but self-complacency was to be deprecated. One must remember, for instance, that in metal construction and geared engines, Germany had gone further than we had. Aeronautics was not a self-contained subject, and help was required, and should be invited from the practitioners of other sciences.

Mr. J. D. North said that Captain Barnwell's ambitious scheme for research by a series of tests on wing forms would involve an enormous mass of work. If one wind channel were set aside for the investigations the whole series would take about 3,000 years. Was it not time to realise that progress by means of trial and error had now been carried about far enough. It was desirable that all existing wind channel data should now be examined and correlated. Turning to some of the detail matters mentioned in the paper, Mr. North went on to say that although the gearing of engines and the use of central engine rooms had certainly been developed further by the Germans than by us, he was not sure that there were not signs of the Germans giving up this line of advance owing to the troubles they had experienced with it. Many of the engine problems mentioned in the paper were general engineering problems and had no peculiar reference to aeronautics. The cantilever wing, which had been mentioned, sounded very nice. Cantilever was a sort of blessed word like "Mesopotamia," but the building of a cantilever wing did not mean that one did away with struts. It meant that one put them inside the wing. The wing struts and ties in an aeroplane were only responsible for some 14 per cent. to 15 per cent. of the residual resistance, and he thought far more was likely to be gained by reducing interference resistance. Merely doing away with external wiring and bracing was not likely to lead to any great advance in aeroplane design.

Professor L. Bairstow said that the greatest advances in the future would probably come from improvements in the engine. Most recent accidents had been due to engine failure. Progress would be from our present aeroplane and not from some new point, and the helicopter and flapping wing machines were not arousing much interest. The present air propeller has an efficiency of about 80 per cent., but the thrust in a modern aeroplane was only about one-third of the weight of the machine, so that the helicopter did not appear to offer much promise. A matter to which more attention would have to be given in connection with the design of commercial aeroplanes was that of stability. During the war the question of safety turned more on rapid manœuvring power than on stability, as was necessary. The best machines were either just stable, or just unstable. The conditions were, however, not the same in commercial work, and it was now necessary to give more attention to stability. In connection with Captain Barnwell's proposed scheme of wind channel research he would ask who it was proposed should carry out the work. Designers certainly could not afford to. As an analogy he might point out that an engineer building a bridge was guided by theoretical considerations. He did not build the bridge and then try if it was strong enough. In the same way we had a theory of aeroplane design, but unfortunately it was so difficult that it could not be applied. One had to try things experimentally, but this had led to the accumulation of an enormous mass of data. This should now be correlated.

Air Commodore R. K. Bagnall Wild said that the first thing which had struck him about the paper was that it had not touched on the spare part question. A greater effort should be made towards simplification of parts. Sheet metal straps, for instance, should be used instead of stampings. This kind of thing led to economy in maintenance. The paraffin carburettor had been mentioned on the paper, but the idea of using the paraffin carburettor did not go nearly far enough. We should get on with fuel ignition and the use of alcohol. He believed alcohol could be produced in the tropics at less than 1*s.* a gallon.

Major-General Sir Sefton Brancker, referring to the question of stability, said that the greatest difficulty at the present time was when flying in a fog or through clouds, and in rough weather. The machines of 1914 were more stable than those we had now. Manœuvreability had improved but stability had fallen back a bit. What was required was a type of machine which normally the pilot would not touch at all. A variable-pitch propeller to enable a machine to get off with a heavy load would be of great value. Once a machine was off it was all right.

Mr. R. Blackburn raised the question of the carrying of merchandise. He said that most of the world's traffic was in the carrying of merchandise, and that this class of trade could be carried on with a less technically developed material than was necessary for passenger traffic. He thought it would be valuable if some indication could be given to designers as to whether it was most desirable to concentrate on goods carrying or passenger-carrying machines.

Mr. Douglas Shaw referred to a number of detail points. Something had been said about the use of steam turbines on aeroplanes and he would point out that the gyroscopic effect should not be overlooked. It was possible that it might be usefully employed. In connection with triplanes he would like to see experiments on the effect of setting the middle plane forward of the other two. In the normal position it was least efficient of the three. In reference to the cowling of engines he would suggest that the engine should be totally enclosed and charges of cooling air taken inside the cowling intermittently. This should lead to more effective cooling.

Dr. A. P. Thurston suggested that one of the most important questions in connection with the design of the commercial aeroplane was the application of some auxiliary method of increasing the lift when getting away and decreasing the speed when landing. He also referred to metal construction, and thought that its development would be along existing lines. The best designs put the metal where it was wanted, and the same thing applied to wood designs. In connection with the use of the steam engine, he would point out that it could not obtain the thermal efficiency which was possible with the petrol engine and that the cheaper fuel which it was proposed to use with it, was of lower calorific value than petrol. This also applied to alcohol.

This concluded the discussion of the paper, and it was announced by the chairman that the author would reply in writing in the official report of the conference.

Service Aviation.

The last day of the Conference, Thursday, October 14, was devoted to service aviation and airships, the morning session being occupied with the reading and discussion of a paper by Air Marshall Sir H. M. Trenchard, Bart., K.C.B., D.S.O., entitled "Aspects of Service Aviation." The chair at the morning session was taken by Admiral-of-the-Fleet Earl Beatty.

Air Marshall Trenchard's paper did not deal with details, its object being to explain the principles governing the formation and employment of the Royal Air Force. War, he pointed out, must be the governing factor of all peace organisation, and modern war conditions necessitated the organisation of fighting services on the cadre principle with great power of expansion. In the Royal Air Force expansion would be very great, and rapid mobilisation was particularly essential since aerial activity would precede contact on land or sea. The Air Force was therefore dependent on civil aviation to an even greater extent than the Navy is on the mercantile marine. Demobilisation, the author stated, had left many blanks and difficulties, and as the Force had practically no peace experience behind it, it must learn by the process of trial and error; criticism would, however, be welcomed. With regard to *personnel*, questions were being asked as to the career offered to officers and men. The Air Force could not take all officers on a permanent basis since a large number of junior officers, and a comparatively small number of senior officers, were required. As regards other ranks the majority of the long apprenticeship trades would be enlisted as boys and given a three year's training. There were two sources of entry for officers on a short-service basis, viz., direct from civil life and seconded from the Army and Navy. The seconding of officers, the author regarded as important, since it was most necessary for the Army and Navy to study the effect of aviation on their own strategy and tactics. With regard to the distribution of the force the ideal arrangement was to concentrate in a few centres with power to move rapidly, but this was difficult to accomplish. Egypt, the author said, was an obvious place for a central reserve. There was no literature on the subject of the employment of the Force in warfare, and, although, in this respect, we had the experience of the war to guide us, this experience was not yet accessible on paper to any extent. A Royal Air Force Staff College was needed to analyse principles and create a school of thought. The rôle of the aeroplane, the author said, was essentially offensive, and aerial predominance could only be achieved and maintained by incessant attack. Surprise, although difficult to attain, was also an important factor. In conclusion the author pointed out that aircraft, if used without forethought and understanding, lost its moral effect and achieved small, if any, material results.

The discussion which followed the reading of the paper was opened by Rear Admiral Sir A. E. M. Chatfield, K.C.M.G., the Assistant Chief of the Naval Staff of the Admiralty, but as many of the points raised in the discussion naturally had reference to purely service questions we propose only to deal with it in a somewhat abbreviated form. Rear Admiral Chatfield spoke on the naval aspect of aviation and said that the Navy fully endorsed all that had been said about civil aviation. He had no doubt that the country that first developed civil aviation would become a great air power. During the war, naval aviation had only developed slightly, though its possibilities were fully realised. Owing to low endurance, aeroplanes could not permanently accompany the fleet unless carried on a ship, and even then there was great difficulty and danger to the *personnel* concerned. In the air reconnaissance of Heligoland Bight in 1914, seven pilots went up and four descended into the sea, the mother ship in the meantime having disappeared. The pilots were, however, picked up by chance. During the war the question of aeroplane carriers had been fully studied, and many capital ships now carried aircraft which could be launched in an action. The problem of using aircraft with fleets, the speaker continued, was now receiving the attention of all naval powers, but the difficulty lie in the fact that aeroplanes could only remain in the air for a short period; although they could travel a great distance in a short time they could not keep the air in the same way that a ship can keep the sea. It was felt that the development of special naval aircraft was essential to progress. Guns and torpedoes, he said, had been largely developed by the inventive and productive power of the great armament firms of the country, and if naval aircraft was to develop equally an equal effort must be made in aircraft factories. The matter, however, was of the utmost importance, and required encouragement. The value of vertical observation by means of aircraft in a naval action was fully appreciated, but it was necessary to be able to rely upon its presence under all conditions, and this problem remained to be solved. After some remarks concerning the seconding of officers from the Navy, the speaker concluded by expressing the view that power to command the sea would depend upon the energy and resource with which the country applied itself to the solution of air problems.

Lieutenant-General Sir Philip Chetwode, Bart., K.C.B., who followed, said the author pressed the need for co-operation between the Army and the Air Force, but that was quite unnecessary, since the value of the new force was so very obvious that the Army could not possibly afford to neglect it. The Air Ministry must, however, exercise patience,

since the Army found it difficult to decide on what lines to proceed to prepare for the next war, but whatever course was decided upon it was certain that the airman would play a very important part. In the late war the spade had enabled them to save time while lethal weapons were perfected, but this instrument could not be depended on in future wars; a war of position, he thought, could not occur again. Staffs were now engaged in digesting the facts and figures of the war, but it would probably be some years before the results of the digestive processes could be presented. The remainder of General Chetwode's remarks had reference to the provision of officers for the Air Force, and in this respect he expressed the view that the difficulties referred to in the paper were more of a momentary than of a permanent character. With patience on both sides, however, he thought a mutually satisfactory solution would be reached.

The discussion was continued by Sir William Joynson Hicks, M.P., who said he did not regret the fact that he was an impatient man. It was necessary, he said, to be ready for any possibility at any moment. They had heard about the scheme for the provision of officers for the Air Force, but had not been told how nearly ready the force was for the possibility of another war. We could not expect peace for a generation, and it was, therefore, necessary to be impatient. The author in his introductory remarks had stated that the Air Force did not claim to have won the war, but the speaker pointed out that if either side had attained complete control of the air, that side would have been victorious. The speaker regarded military aviation as vital, and expressed the view that it was quite impracticable to convert commercial machines for military use. The aeroplane, he said, would act as the long-range artillery in future wars, and for this purpose long-range, fast-travelling machines were needed. With regard to Egypt, the speaker expressed similar views to those reported in our last issue on page 513 *ante*, and in conclusion he moved a resolution to the effect that "This Conference desires to impress upon H.M. Government the vital importance of Egypt to the future of military aviation." There being no amendment to the resolution, the chairman regarded it as having been carried unanimously, although it was not seconded and not formally put to the meeting.

The next speaker was Major-General Brancker, who first dealt with the principles of aerial warfare and indicated that these principles called for the maintenance of a very large air force, far larger, in fact, than was possible from a financial point of view. Although Sir Joynson Hicks had said that commercial machines would not do for military work, the speaker thought they would be of some assistance. A large and efficient reserve was necessary, and the most obvious means of providing this was from a healthy aerial transport industry. Civil aviation, the speaker continued, would pay on the Continent before it did in this country, since, in Continental countries, subsidies were being granted and there were larger areas of land to fly over. In this country it did not pay at present, and nothing was apparently being done by the Government to create an aerial reserve. Certainly the author had not indicated how to produce a reserve on a large scale. The speaker did not agree with the author's view that the independent force should be used indiscriminately for bombing, raiding and other work, and expressed the opinion that the whole Royal Air Force, in the future, would consist of independent air units, while the Navy and Army would each produce and employ their own units. General Brancker also referred to the training of officers and to the inadequate allowance for the Air Force in the Budget.

Colonel, The Master of Semphill, who continued the discussion, read his remarks rapidly from a written document dealing mainly with the technical *personnel* of the Air Force and referring to the difficulty, in the near future, of providing an adequate supply of technical officers. The policy in this respect, he said, was not clear, and he suggested that the status of technical officers had not been sufficiently considered. The air service was mainly dependent on people with technical knowledge, but the number of trained engineers it contained was not large, and their time was largely occupied with administrative duties instead of being devoted to technical matters. Many appointments in the Department of the Director of Research, he added, were now filled by civilians or officers with unique experience on the practical side of aviation during the war, and who had previously received a sound technical training in engineering. These men could not remain indefinitely in that Department, but must refresh their knowledge by practical contact with Service aviation. He asked how these posts were to be filled in the future, and pointed out that it would not be possible to obtain suitable men from outside since some 95 per cent. of the firms engaged on aircraft work during the war had now turned their attention to other matters. He thought the scheme suggested by the Chief of the Air Staff might be feasible when civil aviation had developed sufficiently, but was doubtful as to when this would be the case. Before concluding with some remarks on the training of men, the speaker emphasised the necessity for technical officers to undergo a very thorough training, pointing out at the same time that wide practical experience was equally important for the maintenance of the efficiency of the Force.

The last speaker in the discussion was Sir Eustace d'Eyncourt, who said that the author had alluded in his paper to the possibility of aircraft being carried on mail steamers. The question of constructing ships which could be used commercially in peace and readily fitted as aircraft carriers in war had been considered by the Admiralty, and preliminary designs had been got out. It appeared to be quite a practical proposition to construct an aircraft-carrying mail steamer able to carry about 20 aeroplanes of moderate size in peace time and a considerably greater number in war time. Continuing, Sir Eustace said he had developed the design of a vessel which would have a clear flush deck 500 ft. long and 100 ft. wide, the ship having a total length of about 650 ft. and displacing about 24,000 tons. There would be two large hangars for peace use and an additional hangar in war. There would be good passenger accommodation, and a speed of about 18 knots could be maintained on long ocean voyages, and 21 knots or more on shorter trips. Such vessels would, however, probably require some Government assistance to run, but would form a very economical means of training pilots and providing for the maintenance of vessels. They would also appear to offer facilities for rapid communication with ports or inland localities not hitherto touched by regular mail services. On the subject of the reliability of aircraft, Sir Eustace said it appeared that, although enormous strides had been made, there was even now neither an aeroplane nor an airship capable of making long trans-oceanic flights with certainty. By means of the proposal outlined, however, it would be possible to use the more reliable ocean-going ship for the difficult part of the voyage and to despatch and receive back aircraft which could complete the remainder of the journey. It had been suggested that airships could be used for the whole voyage, but Sir Eustace said he hardly agreed with this. He pointed out that the time taken for the outward journey of the R. 34 across the Atlantic could be equalled by some of our faster ships, such as the Renown, and this could be done with regularity and certainty in any weather, whereas the airship had considerable difficulty in completing her voyage. The main advantages of the scheme outlined would be reliability, and the means provided for linking up outlying districts with mail routes, but the steamers would, Sir Eustace thought, prove very attractive to passengers, since the large flying deck would afford ample scope for recreation. We should also have ships immediately available for use as aircraft carriers in war, and they would serve as a training school for pilots in the art of getting off from and alighting on a ship at sea. The cost of such an undertaking he said, would probably exceed that of an ordinary line of mail boats, but he thought the advantages gained worthy of the expense.

At the conclusion of Sir Eustace d'Eyncourt's remarks, the chairman called upon Air Marshall Trenchard to reply, which he did by saying that all the criticism made on the Air Force was recognised as valuable, and some of the suggestions would be adopted. He proposed a vote of thanks to Earl Beatty for presiding, which was seconded by Lord Londonderry, and after Earl Beatty had briefly replied, the meeting was adjourned until the afternoon.

THE COMMERCIAL AIRSHIP.

At the afternoon meeting, which opened at 3 p.m., Commander Sir Trevor Dawson read a paper entitled "The Commercial Airship—Its Operation and Construction." We give an ample abstract of this paper in another part of this issue (*vide* page 558), and we may accordingly at once proceed to a report of the subsequent proceedings. Before the discussion was taken a resolution was passed asking the Government to review and re-consider the recommendations of the Civil Aerial Transport Committee with a view to their adoption.

Sir James Stevenson opened the discussion. He said he had been on a visit to Croydon the day before, and seeing the two airships hovering overhead, thought they formed an excellent object lesson on the present position of the airship. It was always hovering somewhere in the background. Convenient handling at terminals was really the crux of the whole matter, and he had been glad to hear of the success of the mooring-mast as dealt with in the paper. The country had spent some 40,000,000*l.* on airships, and the question rose as to what we should do with the material we had accumulated. It hardly seemed desirable to have a bonfire, and the ships we had might be obsolete in a sense, but they were quite suitable for the initial steps in commercial airship services, and he thought the Government would be prepared to meet any organisation which would take over and work existing material. Finally, Sir James referred to aerial mails of the future, and said that letters would be photographically copied to a minute scale for transport and re-copied on arrival at their destination.

Air Commodore E. M. Maitland said that the public were inclined to base their ideas of the service value of airships on the results obtained with the German military ships. These results were of no true military value, and the Germans finally saw this, and put the ships on naval patrol work, which was their true sphere, and a very valuable one. On the question of the dangers inherent in the use of hydrogen, he would point out that any risk of fire from this cause was almost entirely a war risk. If helium were available, the war uses of airships would be greatly extended. It was not necessary, however, for commercial service, and the use of petrol was really a greater fire danger than the hydrogen, and this was common to all aircraft. For some time to come, Service and commercial airships would be more or less interchangeable. For both services it was necessary to carry fuel and loads either of mails and passengers or bombs. Regularity of service would be of importance in commercial work, and the promising results of the mooring tower experiments were very satisfactory. The tower should eliminate the trouble of entering or leaving sheds in bad weather, and once away the airship was not a fair-weather craft. Airships in existence to-day could carry our mails to India in five days against the present time of 21 days.

Mr. S. A. Boulton said that from the point of view of the ordinary traveller, the airship was an almost ideal vehicle. He was, perhaps, the only outside civilian who had spent 20 consecutive hours in an airship, and he could not but believe that such a comfortable method of travelling had a great future. As chairman of Lloyds he might say that that corporation had so far found the insurance of aircraft unremunerative. So far not a great deal had been done, however, and he would like to call attention to Lloyds' Record, the first volume of which had been published. It was but a humble beginning, but helped towards its main purpose, which was to give information to insurers. It was valuable to many other people, however. No classification had yet been attempted, but information was being collected with that object in view. He was in sympathy with the idea that commercial

flying should at first receive some State assistance. It had been said civil aviation must fly by itself. This was a clever phrase, but might do much harm. Help was certainly needed at present.

Mr. B. K. Long said that he spoke as a layman, and thought that at present airships were flying some 10,000 ft. above the heads of the general public. It was necessary to interest the public more closely. He had recently spent seven weeks going to Australia and this had brought home to him the enormous benefit which the airship was going to be to the more distant parts of the Empire. The great danger to the Empire was the inefficiency of Empire Government and this inefficiency was largely due to difficulties of distance and time.

Commander Boothby said that as an old airship officer he was very pleased with the general impression of confidence in the airship which now seemed to prevail. Commercial flying was hampered as far as the aeroplane was concerned by the inability to fly by night and in a fog, but the small airship was quite able to do both these things. The day before when the members of the Conference had paid a visit to Croydon, it was a beautiful day, but owing to fog over the Channel some of the aeroplanes of the regular service had been unable to fly. A small airship would, however, have thought nothing of the fog, and would have sailed as usual. He thought large airships might be of value for taking machinery to difficult places up country. The Air Ministry should make arrangements for trials of this kind of employment to be made. They should also do more to carry out experiments and let experience be gained in manœuvring, flying in bad weather, &c. An interesting question was whether an airship could ride at anchor secured to an ordinary mooring buoy in a harbour. Many people thought it could, but it had not been tried. This was the sort of thing the Air Ministry should experiment with.

Mr. A. E. L. Chorlton said that the cost of an airship service appeared from the paper to come out much heavier than an aeroplane service. This was because the initial cost was so high and made State aid more necessary for airships than aeroplanes. The question was a national one as well as a commercial one, and if aid was not given, we would fall behind. In connection with the matter of fuel we knew that in England there was practically no oil, and were told that the total world supply was limited. In looking round for new sources it was worth thinking about the production of synthetic fuels. In flying one wanted the highest calorific value possible. Petrol had a value of 18,000 to 19,000, and if you could from home materials make a synthetic fuel of 22,000 it would be of enormous value. People spoke of alcohol, but its value was only 14,000. The two-cycle engine had been advocated, but its economy would be less than the four-cycle, and so more fuel would have to be carried. He agreed, however, with Sir Trevor Dawson, that lighter Diesel engines for aircraft could be built, and saw no reason why 10 lb. per horse-power should not be achieved.

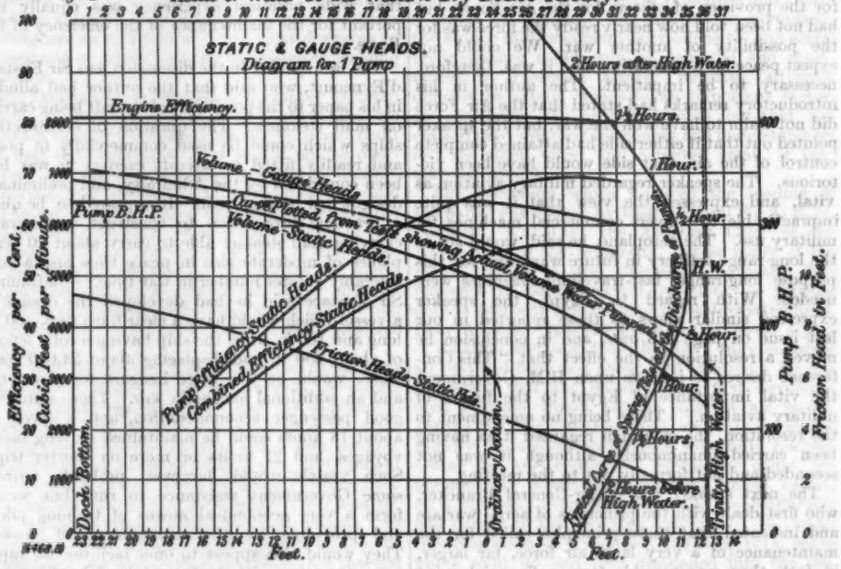
This concluded the discussion of the paper, and after a resolution requesting the Government to call the Conference annually, and various votes of thanks, the meeting broke up.

GAS-ENGINE-DRIVEN PUMPING PLANT AT THE TILBURY DOCKS.

During a critical period of the war, the engineers for the Port of London Authority were called upon materially to reduce the time required to pump out the dry docks at Tilbury, which were then being used for the examination and repair of torpedo craft and other vessels for the Admiralty. It was recognised that the existing steam pumps had become obsolete and needed replacing. A thorough investigation was, therefore, made into the respective merits of centrifugal pumps driven either by "gas," "oil" (Diesel) or "steam" engines, and the decision was given in favour of gas engines to operate from producer gas, and using anthracite as fuel. Two sets of multi-cylinder gas engines were built and installed by the Premier Gas Engine Co., Limited, Sandiacre, near Nottingham (now associated with Messrs. Crossley Brothers, Limited, Manchester). Each engine is coupled directly through its crankshaft to a centrifugal pump made by Messrs. Gwynnes, Limited, of Hammersmith. By the courtesy of Mr. C. R. S. Kirkpatrick, chief engineer to the Port of London Authority, we are able to illustrate and describe this interesting plant.

A diagram of performance of the pumps and a general lay-out of the installation are given in Figs. 1 and 2 on this and the opposite pages, while Fig. 3, on the opposite page, is a cross-section of one of the engines. As will be seen from these illustrations the engines and pumps are arranged in a deep pit, or chamber, forming an engine room with sloping walls. The general appearance of the plant is well indicated in the general views given in Fig. 4 and Fig. 5, on page 534. By sinking the pumps in this manner the suction is materially reduced, and under certain tidal conditions a drowned suction is obtained. This latter makes it possible to obtain the maximum efficiency for the centrifugal pumps. The water enters each pump through piping connected to large drainage culverts arranged below the engine-house floor, and in communication with the various docks to be de-watered. The Gwynne pump impellers are of the double-inlet type with shrouded vanes, smooth finished and carefully balanced. The charging of the pumps, when necessary, is effected by electrically-driven duplex wet vacuum pumps made by Messrs. F. W. Brackett & Co., Limited, Colchester. These pumps

Fig. 1. Head of Water in the Western Dry Dock, Tilbury.



are gear-driven, the gear-box being so arranged that when the pumps are working on vacuum only, they operate at a speed of 92 r.p.m. When it is desired that the pumps should run pumping all water, the ratio of the gears is such as to obtain a reduced speed of 18 r.p.m. A charging pump is provided to each main centrifugal pump, these charging pumps being erected one at each end of the engine-house, as may be seen in Fig. 4 and Fig. 5.

Prior to installing the gas-driven pumping sets the engine-house contained four sets of steam-driven pumps, and the positions of the centrifugal pumps were determined by the existing delivery pipes, which pass through one side of the chamber and are connected with the open channel or discharge pit. Two of the four original pipes were made use of, and the remaining two were blanked off. The delivery from the centrifugal pumps is coupled with a large sluice valve which has a graduated indicator plate above, showing the exact amount of opening at the sluice valve. The opening and closing of this valve is operated by hydraulic pressure at 500 lbs. per square inch to 750 lbs. per square inch, and controlled by slide valves on the supply pipe from the hydraulic main. The sluice valves are each 44 in. diameter, being of the full-way wedge-gate type, made by Messrs. J. Blakeborough & Sons, Limited, Brighouse.

Referring now in more detail to the main pumping sets, it may be said that these consist of two "Premier" four-cylinder horizontal gas engines, each of 368 brake horse-power at normal load, and connected by a flanged coupling on the engine shaft to a Gwynne invincible centrifugal pump. The speed is 200 r.p.m. The gas-producing plant comprises three separate units, one of which serves as a stand-by. They were made by the Power Gas Corporation, Limited, of Stockton-on-Tees, and are of the "suction-pressure" type with the usual complement of scrubbing apparatus. The gas-plant house is situated about 50 ft. away from the engine-house, their relative positions being shown in Fig. 2. The gas from the producer plant is drawn through the washers and coke scrubbers by an exhauster fan, which also forces the gas, at a pressure of a few inches, through the dry sawdust-scrubbers and into the gas main leading to the engine-house. Starting is by compressed air, and with gas ready at the plant, starting from cold to operation at full speed occupies less than five minutes.

In determining the pump capacity required, it was stipulated in the Port of London Authority's specification, that both pumps operating together should be capable of de-watering the Tilbury Western Dry Dock in three hours, or with one set in six hours, when the dock contained 1,825,000 cub. ft. of water. In actual practice the volume of water in the dry dock depends on the height of the water in the main dock. The following figures are interesting and show the results of careful tests made in this direction.

Test No. 1.—One centrifugal pump emptied the large dock in four hours 50 min., when containing 1,680,000 cub. ft. of water.

Test No. 2.—Two centrifugal pumps required 2 hours 40 mins. when the dock contained 1,639,000 cub. ft. of water, and working against the highest tide, 12 in. higher than T.H.W.

In the case of Test No. 1 this gives a discharge rate of 5,793 cub. ft. per minute—against a variable head of minus 1 to plus 29 ft. (30 ft. total). Test No. 2 gives 10,244 cub. ft. per minute against a variable head of 5 ft. to 33 ft. (28 ft. total). Fig. 1, annexed, is a reproduction of a pumping diagram showing the pump volumes, static and gauge heads, to which the plant had to conform. The chain-dotted line has been plotted from a large number of tests taken during the running of the sets and represents the average actual volume of water pumped, with one pump only working.

Mention has already been made that compressed air is used for starting the main engines. The air-compressing plant is by Messrs. Reavall & Co., Limited, Ipswich, and of the quadruplex cylinder type, belt-driven (using a jockey pulley) from a 10 h.p. electric motor. The sets are in duplicate, each compressor having a capacity of 36 cub. ft. of free air per minute. The air is delivered at a pressure of 200 lbs. per square inch into a riveted steel reservoir, which, as shown in Fig. 5, is carried on brackets from the engine-house wall. The cooling water circulated through the gas-engine jackets is provided by pumps driven from the end of the main centrifugal pump spindles.

In the "Premier" multi-cylinder gas engine the governor and side-shaft, shown in the foreground in Fig. 4, are on the free side of the engine, i.e., on the side away from the flywheel. The governor is of the enclosed centrifugal spring-loaded type, highly sensitive, and is directly driven by skew gears from the engine shaft. The governor controls the admission of gas by means of a central throttle valve and is actuated from a weigh-shaft and connecting-rod coupled to the governor lever. The gas after passing through the throttle valve enters a gas manifold pipe coupled to each of the four cylinders through the admission-valve cages. Air enters separately, so that the gas and air, forming a mixture, only unite inside each admission-valve cage, and immediately behind the point of entry into the cylinder. In the event of an occasional back-fire occurring in any one cylinder, this does not disturb the mixture entering

GAS-ENGINE-DRIVEN PUMPING PLANT AT THE TILBURY DOCKS.

MR. C. R. S. KIRKPATRICK, M.INST.C.E., CHIEF ENGINEER, PORT OF LONDON AUTHORITY.

Fig. 2.

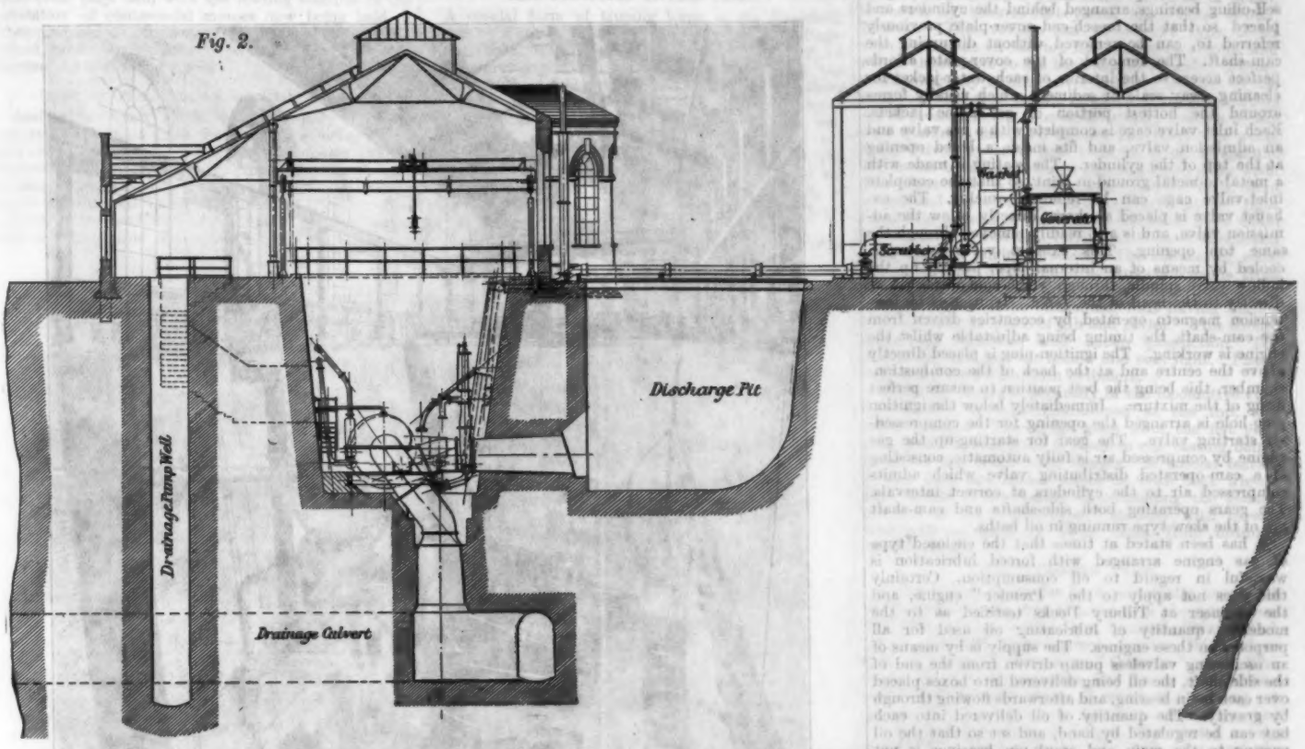
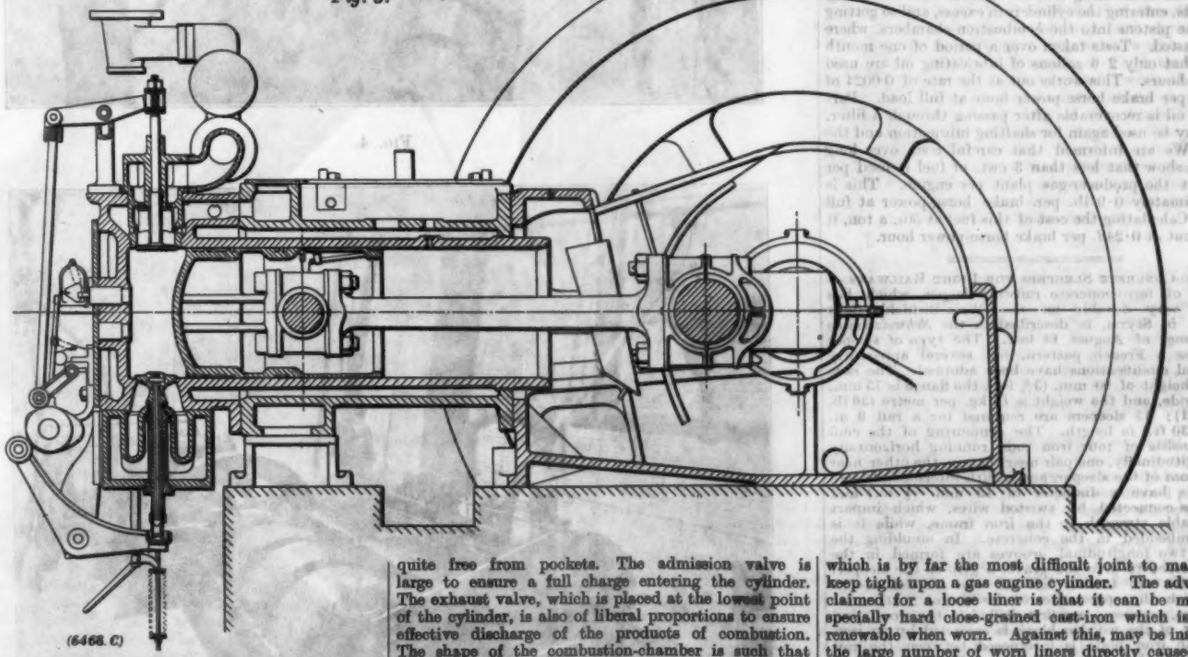


Fig. 3.



(6468. C)

the remaining cylinders, and so the governing is not upset. The gas throttle is specially designed to ensure good control and made easily removable for cleaning purposes. In addition, an air throttle valve is provided to each cylinder, so that, if desired, the strength of the firing mixture can be separately adjusted for each cylinder.

The design and construction of cylinder, combustion-chamber, valves, and cam-operating gear of the engine are clearly shown in Fig. 3. As may be seen, the combustion-chamber is symmetrical in shape and quite free from pockets. The admission valve is large to ensure a full charge entering the cylinder. The exhaust valve, which is placed at the lowest point of the cylinder, is also of liberal proportions to ensure effective discharge of the products of combustion. The shape of the combustion-chamber is such that the clearance volume, when the piston is on the back centre, offers the minimum surface area to the cooling action of the jacket water—thus contributing to the thermal efficiency of the engine. Notwithstanding this, the water passages are ample and give effective cooling where it is most needed.

The design of the cylinder calls for special comment. It will be observed that this engine has no loose liner—such as is generally understood by that term. The cylinder and breech end are cast integral, and form one plain casting, thus dispensing with the liner joint which is by far the most difficult joint to make and keep tight upon a gas engine cylinder. The advantage claimed for a loose liner is that it can be made of specially hard close-grained cast-iron which is easily renewable when worn. Against this, may be instanced the large number of worn liners directly caused by a faulty and leaking liner joint. With the "Premier" design as we have said there is no loose liner, but, on the other hand, the cylinder barrel with breech end form so simple a casting that this can also be made from hard close-grained metal to withstand wear, and be suitable alike for the cylinder-wall surface and exhaust seating. The back of the breech end is cast open, giving perfect access in the first place for the removal of cores and cleaning the casting. A large cover plate as shown, is afterwards attached at the back, which allows for the free expansion of the inside

walls when working under heat stress. As the result of this method of construction, cracked or broken breech ends are claimed to be an unknown quantity upon the "Premier" gas engines.

All valves are operated from a cam-shaft running in self-oiling bearings, arranged behind the cylinders and placed so that the breech-end cover-plate previously referred to, can be removed without disturbing the cam-shaft. The removal of the cover-plate affords perfect access to the interior of each water-jacket for cleaning away scale or sediment which usually forms around the hottest portion of gas-engine jackets. Each inlet-valve cage is complete with a gas valve and an admission valve, and fits inside a bored opening at the top of the cylinder. The seating is made with a metal-to-metal ground-in joint, so that the complete inlet-valve cage can be removed quickly. The exhaust valve is placed as shown directly below the admission valve, and is also readily removed through the same top opening. This exhaust valve is water-cooled by means of an internal pipe, passing up the hollow valve spindle, through which cold water passes directly to the head of the valve. Ignition is by low-tension magneto operated by eccentrics driven from the cam-shaft, the timing being adjustable whilst the engine is working. The ignition-plug is placed directly above the centre and at the back of the combustion-chamber, this being the best position to ensure perfect firing of the mixture. Immediately below the ignition plug-hole is arranged the opening for the compressed-air starting valve. The gear for starting-up the gas engine by compressed air is fully automatic, consisting of a cam-operated distributing valve which admits compressed air to the cylinders at correct intervals. The gears operating both side-shafts and cam-shaft are of the skew type running in oil baths.

It has been stated at times that the enclosed type of gas engine arranged with forced lubrication is wasteful in regard to oil consumption. Certainly this does not apply to the "Premier" engine, and the engineer at Tilbury Docks testified as to the moderate quantity of lubricating oil used for all purposes on these engines. The supply is by means of an oscillating valveless pump driven from the end of the side-shaft, the oil being delivered into boxes placed over each main bearing, and afterwards flowing through by gravity. The quantity of oil delivered into each box can be regulated by hand, and set so that the oil passing to the main and crank-pin bearings is not more than to meet actual requirements. Otherwise, with an enclosed engine there is some possibility of surplus oil lubricating thrown off from the connecting-rod ends, entering the cylinders in excess, and so getting past the pistons into the combustion-chambers, where it is wasted. Tests taken over a period of one month show that only 2·6 gallons of lubricating oil are used per 24 hours. This works out at the rate of 0·0024 of a pint per brake horse-power hour at full load. Part of this oil is recoverable after passing through a filter, and may be used again for shafting lubrication and the like. We are informed that careful tests over long periods show that less than 3 cwt. of fuel is used per hour at the producer-gas plant per engine. This is approximately 0·9 lb. per brake horse-power at full load. Calculating the cost of this fuel at 50s. a ton, it works out at 0·24*d.* per brake horse-power hour.

Ferro-Concrete Sleepers for Light Railways.—A type of ferro-concrete railway sleeper, which has proved very durable on the Weis-Birkfeld light railway, in Styria, is described in the *Schweizerische Bauzeitung*, of August 14 last. The type of sleeper resembles a French pattern, but several apparently successful modifications have been adopted. The rails have a height of 90 mm. ($3\frac{5}{16}$ in.), the flange is 75 mm. (3 in.) wide, and the weight is 18 kg. per metre (36 lb. per yard); 13 sleepers are required for a rail 9 m. (nearly 30 ft.) in length. The armouring of the concrete consists of four iron rods running horizontally and longitudinally, one pair near the top, the other near the bottom of the sleeper, and a fifth intermediate rod. The rods have a diameter of 12 mm. ($\frac{1}{2}$ in.) and are cross-connected by twisted wires, which impart considerable strength to the iron frame, while it is being embedded in the concrete. In moulding the sleeper, two longitudinal grooves are formed in the lower surface to give the gravel a grip on the sleeper. Four holes are further left for the wooden blocks into which the spikes are to be driven; holes for the spikes, or screws, are first drilled in the wood, and the neck of the wooden block is encircled by an iron ring. An iron plate is interposed between the rail flange and the sleeper surface. No spikes have worked loose during the nine years of service of the sleepers, and no other trouble has arisen, although some of the sleepers and rails were laid and put under load after the concrete had been allowed to set for not more than 14 days; this short period was purposely chosen. Small cracks, mostly in the direction of the rails, did form in some cases, but sleepers affected were not removed, nor repaired, and have proved as strong as the others. The sleepers weigh 120 kg. each, three times as much as the wooden sleepers, and the cost was twice as great. The additional cost is considered to be justified by the durability of the sleepers.

PUMPING PLANT AT THE TILBURY DOCKS.

MR. C. R. S. KIRKPATRICK, M.INST.C.E., CHIEF ENGINEER, PORT OF LONDON AUTHORITY.

Fig. 4.

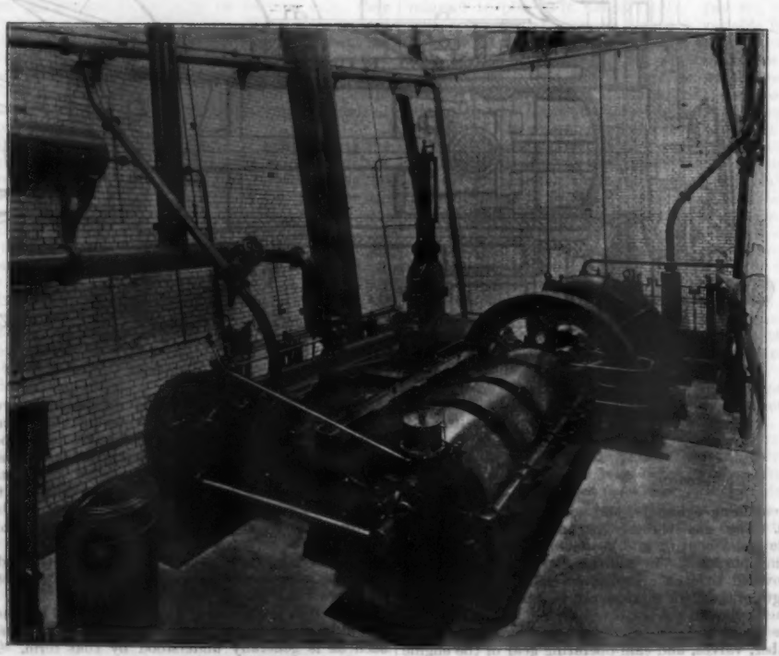


Fig. 5.

EXHIBITS AT THE COMMERCIAL MOTOR EXHIBITION.

We have dealt in another article in the present issue (*vide* page 546) with the leading features of the exhibition of commercial motors now being held at Olympia, and to supplement this we give in the subjoined notes descriptions of certain exhibits which require more detailed notice.

The Albion Lorry.

Among the firms which have previously been adherents of the chain drive, but are now showing a live-axle chassis, is the Albion Motor Car Company, Ltd., of Scotstoun, Glasgow, and 21, Upper Rathbone-place, London, W. 1, who show a new pattern 25-cwt. chassis, which we illustrate in Fig. 1, annexed. This lorry has a worm-driven back axle of the type in which a forging with a banjo-frame goes right across, and has a top cover carrying the worm and a bottom oil cover. Both the drive and torque are taken by the springs. Generally speaking, the rest of the chassis follows generally on the lines of previous Albion practice. The engine has four cylinders cast *en bloc*, the crank-shaft having three main bearings. A detachable cylinder-head is now fitted. The lubrication is, as usual in Albion lorries, by a series of oil pumps, each supplying one of the main bearings, and all worked by a slowly revolving cam, the oil from the main bearings being taken to the crank-pins by centrifugal force. In this system the oil is not circulated, but having once passed through the bearings falls to the bottom of the crank-case and is periodically drained off. Theoretically a circulating system should be more perfect, but the Albion system has the advantage that nothing but clean oil is used, and in practice it works exceedingly well. A single disc-clutch of the usual Albion type transmits power to a three-speed gear-box with sliding gear. A pressed-steel frame is employed, and the engine is carried on two cross-pieces, while the gear-box is carried on an inside frame. This chassis is fitted with electric light, the current for which is supplied from a special dynamo fitted with a centrifugal governor acting on a special type of clutch.

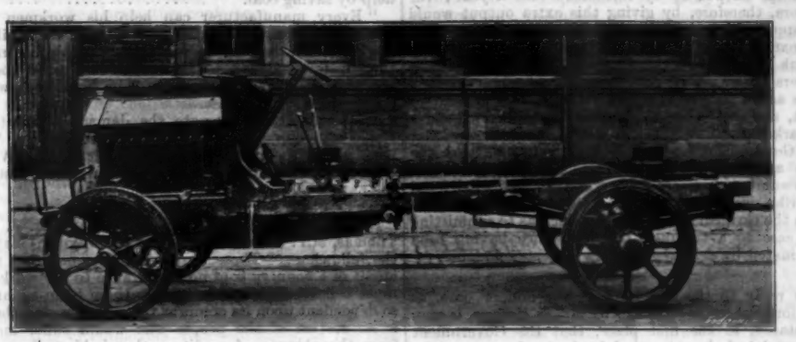


Fig. 1. Chassis for Lorry; The Albion Motor Car Company, Limited, Glasgow.

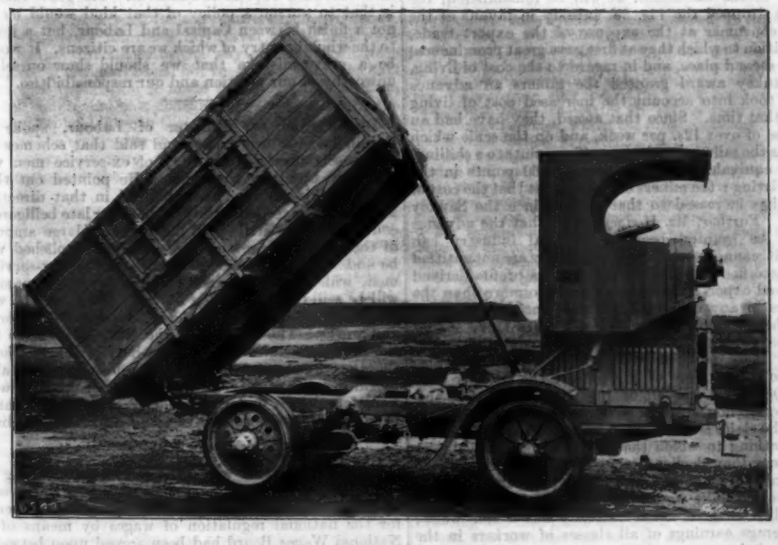


Fig. 2. Pagefield Tipping Lorry; Messrs. Walker Brothers (Wigan), Limited, Wigan.

The Pagefield Tipping Lorry.

A special form of tipping lorry is the Pagefield, shown by Messrs. Walker Brothers (Wigan), Ltd., Pagefield Works, Wigan, which we illustrate in Fig. 2, on the present page. This vehicle will carry 3½ tons, but is of very short wheel base, being intended for making deliveries in places where a long vehicle would have difficulty in manœuvring. The wheel base is, in fact, only 8 ft. 2 in. and the vehicle will turn in a 36-ft. circle. In order to accomplish this result the engine is placed entirely in front of the front axle, and the driver is placed above it, so that the front wheels are about level with the front of the body.

Tipping is done mechanically. A shaft driven from the gear-box transmits power to a pinion in mesh with two bevel gears on a cross-shaft. Either of these wheels can be locked to the shaft, the one giving the motion for tipping, the other for lowering. From this shaft the screw of the tipping gear is driven by a bevel. A safety arrangement, consisting of a nut travelling on a thread on the cross-shaft, throws the bevel out of gear when the body has reached the end of its travel, either at the top or bottom, and when the bevel gear is in neutral position the cross-shaft is automatically locked.

The engine is a 40-h.p. Dorman, transmitting power through a four-speed gear-box to a worm-driven back axle of the type with a forged "banjo-frame" and top and bottom covers. Both torque and drive are taken by the back springs. A pressed steel frame is used, having an underframe to carry the engine, while the gear-box is carried on two tubular cross-members. A chassis of ordinary wheel base is also shown having the same general features as above, except for the wheel base and the fact that the driver is placed in the usual position behind the engine.

Steam Lorry by Messrs. Robey and Co., Ltd., Lincoln.

A steam lorry of the familiar "over type" in general outline, but having a good many novelties in detail, is shown by Messrs. Robey and Co., Globe Works, Lincoln. This vehicle has locomotive type boiler with the engine on the top like a traction engine, and a long chain drive to the back axle in a similar manner to the majority of the "over type." In place of the usual channel steel frame, however, the side members are of pressed steel. The steering is by a worm acting on a quadrant direct on the steering pivot, the worm being driven by bevel gear from the steering spindle. The usual barrel and chains are thus done away with. The front axle is placed rather further back than usual, and the steering wheel is placed at the right hand side instead of the left, as has been more usual in traction engines and lorries which have developed from traction engine practice. The connecting rods, eccentric rods, links and drag links are made from stampings, the connecting and eccentric rods being of H-section and the connecting rods having marine type big-ends in place of gib and cotter. This should make for lightness and cheap production. The pins of the link gear are hollow and very light. Piston valves are used with both cylinders.

While the boiler is generally of the locomotive type the fire-box is cylindrical-domed at the top, and without stays. The gauge glass is of the flat glass type, and the mounting is made in one casting bolted direct to the boiler with flanges. A special feature is that there are brakes direct on both back wheels. The vehicle is interesting as combining the general features of the "over-type" steamer with several modifications, some of them taken from ordinary motor practice.

The "Commer" Car.

A firm which has so far been principally known for chain-driven lorries, but which is now showing a live-axle type, is Commercial Cars, Limited, Biscot Road, Luton, and 168, Regent-street, London, W. 1, whose cars are generally known as "Commer" cars. This chassis is of 2-ton capacity, and has a worm-driven axle the differential casing of which is a casting. A torque tube is used to take the drive and torque, and this is relatively short in length, there being a long intermediate shaft between the ball joint and the gear-box. Commer lorries have always been distinguished by the fact that the gears did not slide into gear but were all changed by dog clutches. This practice is followed in the present model, but the clutches are no longer put into engagement with springs as previously, but are changed by a lever working in a gate. Three speeds are provided, of which the top is direct and the second always in mesh, while the first is arranged so that the wheels come into mesh before the clutches engage. The rest of the chassis follows generally on previous Commer practice. The engine is four cylinder, 100 mm. by 120 mm. (approximately 4 in. by 4¾ in.), and has the valves all on the same side, and the crankshaft carried on ball bearings. It is carried on a three-point suspension. A cone clutch is used, and the frame is of pressed steel.

The Saurer Tip-wagon.

A 3-ton lorry chassis having some interesting points is shown by the Société Anonyme Adolphe Saurer Arbon, Switzerland. The principal features of interest are that, although among the heavy lorries, its main features of construction follow the lines more usual in the light car, as it has the engine and gear-box combined in one unit, and a bevel-drive back axle with a single reduction. We illustrate the back-axle unit in Fig. 3, and the engine and gear-box unit in Fig. 4, on page 542.

The bevel drive has become almost universal in the light car, where the reduction between the engine and back wheels has generally been in the neighbourhood of 4 to 1, but it has not been usually considered practicable to apply it to the heavier vehicles, where a very much bigger ratio is required. In this case, however, the pinion has seven teeth, and the crown wheel 56 teeth, so that the reduction is 8 to 1, which is enough for any ordinary heavy lorry. The axle is built up in the manner common in light cars, with a centre casting to which two taper tubes are bolted. Both brakes are on the rear wheels, and all bearings are ball bearings. The engine and gear-box unit is also a feature which has become general on light cars, though it has usually been considered that it was better in the heavier vehicles to have two separate units. There are, however, many advantages in having a single unit, as the engine and gear-box are then erected in line on machined facings, and are certain to remain so, no flexible joints between the engine and gear-box being required.

The engine has four cylinders, 100 mm. by 170 mm. (4 in. by 6¾ in. approximately), with all the valves on the same side. Ball bearings are used for the main bearings of the crank-shaft and for the camshaft. The

engine is fitted with a governor and set to run at 1,000 revolutions per minute, while there is a special arrangement whereby the engine is governed to 800 revolutions per minute when on the top speed. There are many advantages in this arrangement, for it is notorious that if the governor solely acts on the engine speed, it is either too fast for the vehicle on the top speed or slower than necessary on the lower speeds. A cone clutch is used which has special tongue pieces on the flywheel forming springs so as to take the drive up more smoothly. The gear-box is of the usual four-speed type, with direct drive on top. The unit is carried on a three-point suspension, there being two supports at the back and one in front. The springs are very wide and long and are practically flat, the width of the springs being 3½ in. back and 2½ in. front. Both the drive and torque are taken by the back springs, a very long propeller-shaft with joints at both ends being used. The frame is of pressed steel of very simple design, and consists of two straight side-members and three cross-members, no inside frame being used. The wheels are of the artillery type. The whole chassis seems extremely well worked out in detail, and it will be interesting to see how it actually performs in practice compared with vehicles of more conventional design.

A very ingenious tipping body is shown by the above firm which allows of the load being tipped from either the back or either side at will. This is shown in Figs. 5 and 6 on page 542, the former showing the back tipping, the latter side tipping. The whole body is carried on four ball joints. These are so arranged that the two front joints or the two on either side can be released by the driver, the others being held fast. The centre of the body can be raised by a hydraulic ram supplied with oil under pressure by a pump driven from the engine. The body then tips in the desired direction. The locking of the joints and the action of the ram are all controlled from the driver's seat.

The New Omnibuses of the London General Omnibus Company.

Considerable interest attaches to the omnibus shown at the stand of the Associated Equipment Company, Limited, Blackhorse-lane, Walthamstow. This firm builds the omnibuses for the London General Omnibus Company, and the example shown has the same chassis as the "K" type 'bus which is now making its appearance on the streets. It is therefore interesting to note the differences between the new type vehicle and the one which has long been a familiar feature on the London streets. In the first place the engine is completely re-designed and now has the valves all on the same side instead of on opposite sides, while the cylinders have been reduced in diameter, the stroke remaining the same. The dimensions are now 100 mm. by 140 mm. (approximately 4 in. by 5½ in.). The valves are not enclosed, as is now almost universal practice, and non-adjustable tappets are used. There are some distinct advantages in both these points for the enclosing of the valves, although it makes the engine hood neater, also prevents the heat getting away from the valve springs, &c., so freely. The non-adjustable tappets also have the advantage that they cannot be wrongly adjusted. A Zenith carburettor is now used with a water-jacketed inlet pipe. Chain is used as before to drive the camshaft and magneto, and lubrication remains by troughs under the big ends. Water circulation is now secured by a pump in place of thermo-syphon.

The cone clutch has been replaced by a multiple disc which should make the starting much more smooth than that of the old type. A chain-driven three-speed gear box is still used, but this has been made much more compact than in the older type. It is placed a considerable distance behind the engine. Worm drive is provided to the back axle, but the worm is now below the axle in place of being above it, and the engine is inclined so as to bring the universal joints in line at normal load.

The frame is of wood strengthened with steel plates as formerly. The drive from the back axle is taken by the springs, but the torque is now taken by a torque rod which is very much shorter than usual. The driver in this new pattern of vehicle is placed alongside the engine, in consequence of which the steering rod runs across the vehicle in place of being longitudinal. The weight of this chassis is stated to be 2 tons 6 cwt., and that of the complete single-deck 'bus for 32 passengers 3 tons 6 cwt.

The same firm show a 4-ton tipping lorry having an engine with cylinders 120 mm. by 150 mm. (approximately 4¾ in. by 6 in.), four-speed gear-driven gear-box and worm-driven axle with the worm overhead. The tipping arrangement in this case consists of a hydraulic ram at the front end of the body supplied with oil from two reciprocating pumps placed in an oil tank. These are driven by a shaft from the gear-box. A three-way cock is provided to control the oil. The lowering of the body is carried out by means of gravity.

INDUSTRIAL NOTES.

Since our last issue the miners throughout the country have ceased work, the conference of miners' delegates having decided by a large majority that there was no alternative to a strike. In this connection it is interesting to put on record a statement bearing on the present crisis and made as early as August 18 by Mr. William Brace, M.P., a prominent miners' leader. "It seemed to him," he said, "that there was not sufficient in the dispute, if dispute it may be called, between the Government and the miners to justify such a calamitous thing as a coal strike or a lock-out." Of late, other miners' leaders, including Mr. R. Smillie, Mr. W. Straker (Northumberland Miners), Mr. Herbert Smith (Yorkshire Miners), have also advocated the acceptance of the Government's offer. Mr. Vernon Hartshorn, M.P., stated two weeks ago that an increase in output of only three-quarters of a hundredweight per day per man was necessary to send the output up by 10,000,000 tons a year; the miners, therefore, by giving this extra output would be approaching the rate at which they would be paid an extra 2*s.* 6*d.* per shift. At the same time Mr. Frank Hall (Derbyshire Miners) pointed out that the miners had already produced coal at the rate they were asked to reach for receiving the 2*s.* increase per shift, and Mr. John Baker (Midland Miners) made a remark to the same effect, pointing out to the men that the Government's proposals would yield all that the men asked for. Notwithstanding these views held by a number of miners' leaders, the conference delivered a strike declaration without any further consultation with the Government or with the men as to submitting the case to a tribunal, the conference having been dominated by delegates holding extreme opinions.

In reply to the statement of the miners' case, as put forward a few days ago by Mr. F. Hodges, it may be stated, in the first place, that the Government duly weighed the miners' claim for an increase of 2*s.* per shift, and decided as trustees for the public that it could not be granted; at the same time, the Government offered the arbitration of an impartial tribunal. (Early in the discussion, as will be remembered, the miners dropped the 14*s.* 2*d.* subsidy in favour of the home consumer at the expense of the export trade, a condition to which they at first gave great prominence) In the second place, and in regard to the cost of living, the Sankey award granted the miners an advance which took into account the increased cost of living up to that time. Since that award, they have had an increase of over 12*s.* per week, and on the scale which governs the railwaymen's wages (five points to a shilling) this is equivalent to an increase of 60 points in the cost of living; the miners do not suggest that the cost of living has increased to that extent since the Sankey award. Further, Mr. Hodges' claim that the advance should be granted because the coal industry can afford it, cannot stand, since the miners are not entitled to dictate in what manner any surplus profits derived from coal exports are to be applied, no more than the workers in any other industry are entitled to direct that the proceeds of the Excess Profits Duty should be taken from the general community and distributed among these particular workers. Mr. Hodges also said the leaders were willing to have the advance date from October 1 instead of July 14, adding that this was a concession which meant a heavy sacrifice in wages. Since the claim is not in itself justifiable, it is a sacrifice of something to which the men are not entitled; at all events they declined to bring the point before an independent tribunal. He also added that the 2*s.* advance per shift was sorely needed. To this it can be replied that the miner already has a fair wage; the average earnings of all classes of workers in the mining industry are 225*l.* per year, for five days work only per week, and on reduced working hours on those five days. The miners would get more money by working more regularly; under the Government's offer they would get the extra 2*s.* per shift on giving the output which ruled during the first three months of the current year. It is difficult to see why the miners should not agree to a decision being given in their case by an impartial tribunal. The Industrial Court during the last twelve months has heard and decided 500 cases, it is quite able to deal with the miners' case, and the Government would abide by its award.

Last Saturday the Prime Minister issued the following statement, which forms the best summary that can be given of the present state of affairs in the coal industry:

"The nation is confronted with a coal strike. The Government has made every effort consistent with its duty as trustee for the people to avert this calamity. The proposals of the Government have been supported by many of the most responsible leaders of the Miners' Federation. They have been regarded by all sections of the people as fair and reasonable.

"The Government offered to submit the miners' claim for an increase in wages to an impartial tribunal and to abide by the result. This offer the miners have refused.

"The Government offered to give the increase asked for if the miners would restore the present low production of coal to the figures of the early part of the present year. This, too, the miners have refused, against the advice of some of their most experienced leaders.

"They are attempting now to gain their ends by force. The nation must and will resist such an attack with all its strength; and there can be no doubt as to the issue.

"All citizens must help each other to lessen the inconvenience and suffering which the miners' strike will cause.

"The supplies of coal for public services are sufficient.

"The Government will ensure the fair distribution of available supplies of coal. Every householder can help by saving coal.

"Every manufacturer can help his workmen by making his supplies of coal last as long as possible. There should be no cessation of employment until that misfortune cannot longer be avoided, and above all, the people should remain calm and deal with emergencies as they arise.

"No one need underrate the damage which this strike will do. But no one will be dismayed. We have been through much more difficult times. With a steady purpose and a determination to do justice the nation will overcome all its difficulties."

Speaking at Cricklewood last Saturday, Mr. J. H. Thomas, M.P. (National Union of Railwaymen) stated the following: "Those people who assumed that the credit of a country is of no importance to the workers must believe me when I say that there is no country so dependent upon its credit as this country, and there is no section of the people who would suffer more from the absence of credit or the shaking of credit than the workers themselves. I would utter a warning to those people on either side who think that we have got to make this (the coal strike) a stand-up fight to a finish between Capital and Labour. The grave danger is that to pursue a policy of that kind would mean, not a finish between Capital and Labour, but a finish to the whole country of which we are citizens. It would be a grave mistake that we should show ourselves unworthy of our position and our responsibilities."

Dr. Macnamara, Minister of Labour, spoke at Cardiff last Saturday also, and said that schemes for the re-settlement in industry of ex-service men will be badly upset by the strike. He pointed out that hitherto this country had achieved in that direction a success not excelled by any of the other late belligerent countries. The strike will mean that a large amount of the work of re-settlement so far accomplished will be undone, and the registers of unemployed ex-service-men, which on October 8 contained 158,000 names, will be still further swollen by the ex-soldiers who will inevitably be displaced by the closing down of factories and works. The working of the National Scheme for the Employment of Disabled Ex-Servicemen, of whom there are about 20,000 still to be absorbed, will also be thrown out of gear, and thousands of the men who were found jobs under the scheme on their discharge from hospital will now have to be added to the lists of unemployed.

The coal situation was discussed at the opening of Parliament last Tuesday, when Mr. W. Brace proposed as a temporary measure, and until a permanent scheme for the national regulation of wages by means of a National Wages Board had been agreed upon between coalowners and workmen, that the 2*s.* per shift increase should be paid, but should be reviewed in the light of the results obtained at the end of the current year. In return for the 2*s.* increase he promised that the miners would take an active interest in increasing output. Between now and December 31 a National Wages Board should be set up on agreed lines for the regulation of the miners' wages. He also proposed that a joint committee of coalowners, miners and representatives of the Mines Department should be formed to determine the proportionate shares that the coalowners, the miners and the State should draw from the mining profits pool. The Prime Minister pointed out, in the course of his reply, that in matters of this kind mere promises of improvement could not be accepted at their face value, although he did not question in any way the good faith of the miners' representatives. He considered it necessary to adopt the methods of science, which tested the value of predictions by comparison with the past. He reminded the House that when the former claim for an increase of wages was advanced assurances were given that output would go up, for the payment of more wages would encourage the miners to greater exertions.

That demand was granted, and since then output had gone down steadily. He was sorry to say that in some cases the increase in wages had had something to do with the fall in production. He did not urge that that was the sole cause, but he added that there was no doubt that a certain number of miners found that by working a limited number of days they earned as much money as they wanted, and felt no inducement to put in a full week. It was far better, he said, to talk frankly. In conclusion, he stated he was prepared to adopt Mr. Adamson's suggestion of a fresh conference to go into the proposals made by Mr. Brace, provided that there was some chance of a successful issue, but there was nothing worse than having a conference doomed to futility because the parties had taken up rigid positions from which they were not prepared to recede. From his experience, he was very much afraid of meetings which did not lead to anything, because they only aggravated the position. Therefore, he would like to explore what the chances were before definitely undertaking to summon what might turn out to be a premature conference.

A delegate conference of the National Union of Railwaymen was held last Wednesday with a view to consider the attitude to be taken by the railwaymen in regard to the coal strike. No final decision was arrived at, and although the conference was adjourned the issue was uncertain when we went to press.

Quite apart from the situation in the coal trade, a deadlock occurred a few days ago in the commercial road transport industry, over a claim made by the men for a minimum weekly wage of 4*l.* 7*s.* The point was discussed at a delegate conference of the commercial road transport section of the National Transport Workers' Federation held in London last Tuesday. Another conference was held last Wednesday. There was held at the Ministry of Labour, also on Wednesday, a meeting of employers' representatives, at the close of which the following statement was issued: "The three national employers' organisations in the road transport industry met Sir David Shackleton at the Ministry of Labour, to discuss the application by the National Transport Workers' Federation for a minimum wage of 4*l.* 7*s.* a week for the road transport industry. The employers informed Sir David that there were insuperable difficulties in the way of dealing with the claim on a national basis, but they were willing to deal with the application if made locally." This decision of the employers was considered at a meeting of the federation held later in the day, when Mr. Bevin stated that as the employers declined to negotiate nationally, the federation were consulting with the individual unions to take the necessary steps to enforce the claim.

Three Emergency Orders have been issued by the Board of Trade, namely, the Coal (Emergency) Order, 1920, the Gas and Coal Order, 1920, and the Lighting, Heating and Power Order, 1920. The Coal (Emergency) Order has been issued on the declaration of the Secretary of Mines that a state of emergency exists as and from 1 a.m. on October 16. The general effect of the Order is to limit the purchase or delivery of coal for household consumption to 1 cwt. per week, and to prohibit persons who have more than 10 cwt. in stock from obtaining coal for household consumption. The weekly consumption of coal in factories, workshops and other business premises is restricted to not more than 50 per cent. of the average weekly consumption during the four weeks ended October 16. The Gas and Coal Order provides that in the production of gas there shall not be used a greater amount of coal than will suffice to produce gas of a calorific value of 450 British thermal units gross per cubic foot. It is also provided that gas undertakings shall supply gas in such a way as to spread the consumption of coal over as long a time as possible. Under the Lighting, Heating and Power Order public lighting is to be reduced and skysigns and illuminated advertisements are ordered to be extinguished; there must be no illumination of premises for advertising purposes or display, and the inside lights of shops must be for the actual conduct of trade.

The Minister of Labour states that employment on the whole showed a decline during September. The percentage of unemployed among the members of trade unions (mainly skilled workpeople) from which returns are obtained was 2·2 at the end of the month, as compared with 1·6 a month previously, and the percentage unemployed among workpeople (skilled and unskilled) in the industries covered by the Unemployment Insurance Act was 3·80 on October 1, as compared with 2·88 on August 27. The number of men and women on the live registers of the employment exchanges was 311,126 at September 24, as compared with 281,032 at August 27. In many of the principal industries, including coal mining, building, and agriculture, employment continued good, but in others, including engineering and shipbuilding, it was not so good as in the previous month, while in most sections of the textile trades, and in the leather, boot and shoe, and ready-made clothing trades it was slack. The number of trade disputes, involving stoppages of work, reported to the Department as beginning in September was 93. In addition to these new disputes, 119 disputes which began in previous months were still in progress at the beginning of September. The total number of workpeople involved in all disputes (including workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 104,000, as compared with 86,000 in the previous month and 655,000 in September, 1919. The estimated aggregate duration of all disputes during the month was about 1,135,000 working days, as compared with 768,000 days in August, 1920, and with 3,074,000 days in September, 1919. In the industries for which statistics are available changes in rates of wages reported to the Department as having been arranged to come into operation in September resulted in a total increase of 49,100*l.* in the weekly wages of 219,000 workpeople. Changes in hours of labour affected about 1,500 workpeople, whose working week was reduced by an average of nearly three hours.

SILICA BRICKS OR FIRECLAY BRICKS FOR COKE OVENS.—During the discussion of a paper by Dr. J. Enzenauer on the "Coke Works of the Rheinische Stahlwerke, A. G. Duisburg-Meiderich" (*Stahl und Eisen*, October 7 last), particular attention was paid to the question whether coke ovens should be built in clay bricks or in silica bricks. On the Rhine the common material used to be "chamotte" bricks containing about 20 (15 to 22) per cent. of clay and 80 (77 to 85) per cent. of silica; in Silesia the clay percentage figure was higher, up to 36. Recently a preference has been developing for silica bricks, which were said to be giving complete satisfaction in America. It was objected, however, that silica bricks (dinas stone) answered so long as the coke ovens were kept in uninterrupted use, but began to crack when the ovens had to be shut down; further, that coal washed with water containing salt and moist coal would ruin silica bricks even more rapidly than clay bricks. Both these objections were found groundless at Meiderich and in other plants. At Königsteele 70 chamotte coke ovens had been started in April, 1914. Most of them, Dr. Wollenweber stated, failed within the same year, apparently because the stone softened sufficiently in the hottest portion to make the walls yield; the contractors acknowledging their liability put up superior clay bricks in some cases, and silica bricks in others; the latter are still in good order after four years of service, whilst the former all require repairs. These and other experiences are particularly noteworthy, because the ovens received some rough treatment during the war, and were not always charged with the most suitable fuels; the silica bricks used were, moreover, in some instances of poor quality. Even combined clay and silica bricks seem to be durable, and Wollenweber recommends that the parts most exposed to temperature fluctuations should be of clay bricks. Otherwise silica bricks appear preferable chiefly owing to greater freedom from partial fusion, slaking and warping of the walls; by thus eliminating repairs the capacity of the ovens is increased to a considerable extent.

INFRA-RED RADIATION THROUGH COLOURED GLASS SCREENS.—In various pyrometers use is made of coloured glass screens, and the question arises, in how far the transmission of radiations through these screens is affected when the glass becomes hot. Investigating these temperature effects on infra-red rays, George Rosengarten made use of a spectrometer of the following construction: The rays, entering the spectrometer box through a slit, fall on a silvered mirror, and are sent, with the aid of two more mirrors, through two rock salt prisms in such a way, that the rays are refracted on entering the first prism and again on leaving the second prism, the first as well as the second entrance being normal; the rays finally fall on a thermopile, and the whole prism system can, with the help of a screw, be turned so that different rays are brought to focus on the thermopile. The glasses tested were discs, up to 5 mm. in thickness, 25 mm. in diameter, of blue-purple, blue-green and other shades; they were mounted in a tube which was wound with a resistance coil. The source of light was a tungsten lamp, the rays of which passed through the glass under test and through the slit into the spectrometer box. The wave length λ of the radiations examined ranged from 1 μ to 5 μ, and the temperature of the glass was raised up to 500 deg. C. No distinct temperature effect was observed. There were differences in the transmission amounting to about $\pm$ 8 per cent., but those differences might be due to errors of observations in the difficult experiments. The result is rather surprising, though Rosengarten (*Physical Review*, September, 1920), does not point this out. In previous similar experiments with visible radiations, K. S. Gibson, of the Bureau of Standards, had found that the absorption of visible rays by coloured rays increased on the whole, as the temperature was raised from $-$ 180 deg. to $+$ 430 deg. C.; but the absorption for certain λ actually decreased, and the temperature effect was very strong in some cases. Thus it was found that a red glass which was quite transparent to λ 0·66 μ at $-$ 180 deg. became nearly opaque to these rays (sodium light) at 430 deg.

GAS IN STEEL PRODUCTION.

SIR ROBERT HADFIELD, Bart., delivered his presidential address to the British Commercial Gas Association, on the occasion of their ninth annual conference at Sheffield, last Tuesday, the 19th inst. After dealing with economical matters of general interest, and stating that the nation needed at the present time decreased cost per unit of production, decreased coal consumption per unit of production, increased production of wealth per ton of coal used, decreased expenditure on transport, reduced cost of building, all combined with a decrease of strain on the workers rather than an increase, Sir Robert said that Sheffield was greatly interested in the production of both coal gas and producer gas; this latter was now almost universally used to produce the high melting temperatures, 1,600 deg. to 1,800 deg. Cent., required in the manufacture of steel in the open-hearth furnace.

Probably 80 per cent. of the world's output of steel was made by the open-hearth process. For the present year the total steel production of the world, by all processes, will amount to something like 70,000,000 tons, including the output by the United States which, alone, is expected to reach about 42,000,000 tons. The average quantity of coal used is about 6 cwt. per ton of steel melted, so that at least 25,000,000 tons of coal are now being used over the world, probably involving the production of no less than 3½ million million cubic feet of gas for use in open-hearth steel furnaces also throughout the world. This showed that metallurgists were indeed very large consumers of gas. Some 45,000 cub. ft. to 60,000 cub. ft. of producer gas from coal will melt one ton of steel, the thermal units in the fuel being 9,400,000 British thermal units, and probably no more than 13·5 per cent. of the heat efficiency available was utilised, the greater part, or 86·5 per cent. being lost.

Experience in the use of town gas for fuel purposes had convinced his firm that, given sufficiency of pressure and consistency of quality at a moderate price, coal gas had great possibilities of utility in manufacturing processes of all descriptions in the future. The extended adoption of what Sir Robert preferred to call the productive distillation of coal, in place of its truly destructive combustion, not only secured many direct advantages for industry and for all individual citizens in their homes, but it also secured for the nation, as a whole, important gains in the shape of decreased coal consumption per unit of production, increased production of wealth per ton of coal, decreased demand and expenditure upon our transport facilities, reduced cost of building, which were precisely the nation's needs as stated in one of the opening and general sections of his address.

An interesting point made by Sir Robert in his concluding remarks was to the effect that the gas suppliers should not rest content with delivering good gas regularly to their consumers, but should also see that the consumers, whether domestic or industrial, employed the most efficient gas appliances and, further, that those appliances were constantly maintained in efficient order.

THE MOTOR-SHIP "LOBOS."—The twin-screw motor ship Lobos was launched on the 14th inst. from Harland and Wolff's Greenock shipyard. The dimensions of the vessel are: Length, 419 ft.; breadth, 54 ft.; depth to shelter deck, 35 ft. 3 in.; and gross tonnage, 6,800. The ship has been built for the Pacific Steam Navigation Company, and is classed 100 A1 at Lloyd's. There are seven watertight bulkheads, all carried up to the shelter deck, dividing the ship into five cargo holds and a motor room. The shelter and upper decks extend all fore and aft, while the main deck is fitted only in the cargo holds, and above the shelter deck are the poop, bridge and forecastle decks. A few staterooms for passengers are provided in the bridge space. Twenty-one derricks constructed for loads of from 3 tons to 40 tons are carried on the masts and samson posts, and 12 electrically-driven winches are provided to work the cargo. The windlass and warping capstan are also electrically driven, and the steering gear is of Harland and Wolff's electric type. The vessel is designed to carry a large cargo on a draught of 27 ft., and to maintain a mean speed at sea of 11½ knots. The propelling machinery consists of two six-cylinder four-cycle Diesel oil engines, of Harland and Wolff's standard type, on the well-known Burmeister and Wain system. The engines develop a normal horse-power of 3,200 i.h.p., at 115 r.p.m. In the port side of the engine room are fitted three 100-kw. electric generating sets, each set driven by a three-cylinder four-cycle Diesel engine of Harland and Wolff's standard type, and generating direct current at 220 volts. All the engine room auxiliaries are driven by independent electric motors with the exception of a small emergency steam-driven air compressor; and a small oil-fired vertical boiler is installed for generating steam for fire-extinguishing and heating purposes. The very complete installation of electrically-driven machinery worked by auxiliary Diesel engines affords a very high degree of economy, as the consumption of fuel oil for running all the auxiliaries of the vessel at sea amounts to only a small percentage of the consumption of fuel oil for running the main engines.

2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

CONSTRUCTED TO THE DESIGNS OF MR. J. T. WALLIS, CHIEF OF MOTIVE POWER, PHILADELPHIA, PA., U.S.A.

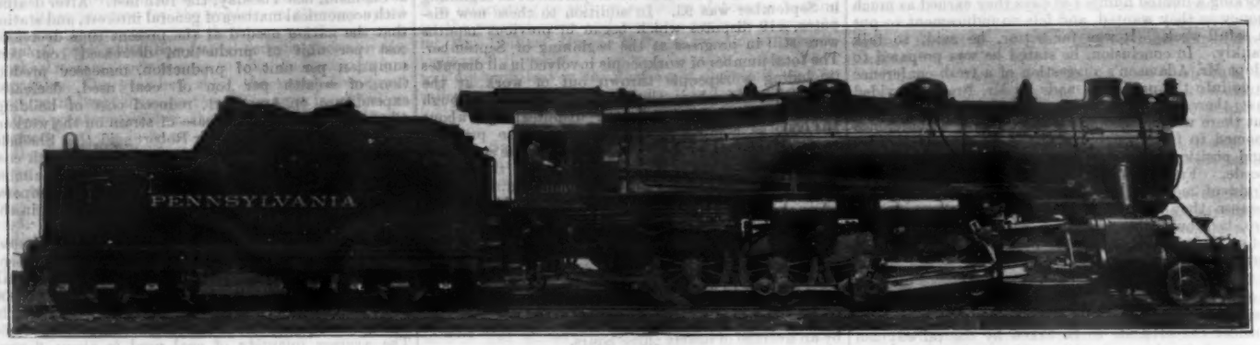


Fig. 15.

Fig. 16.

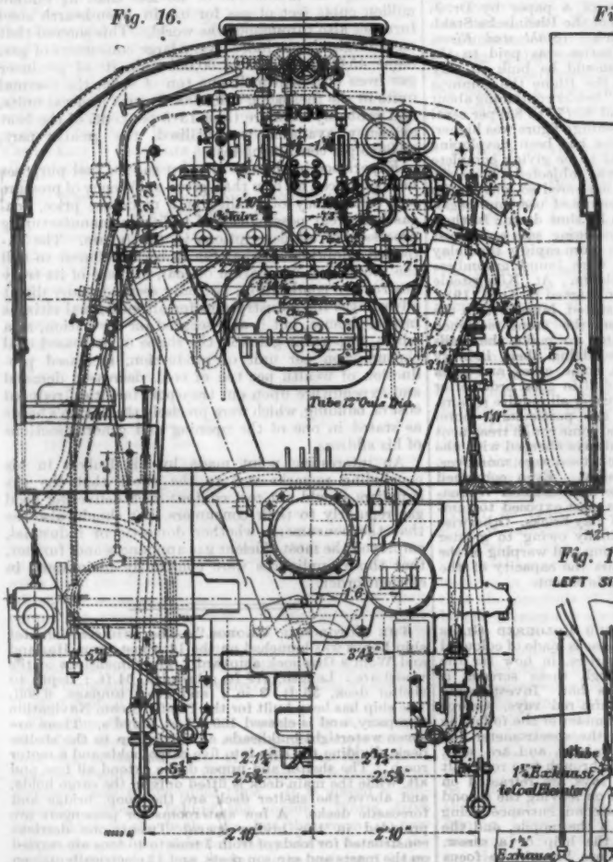


Fig. 17.

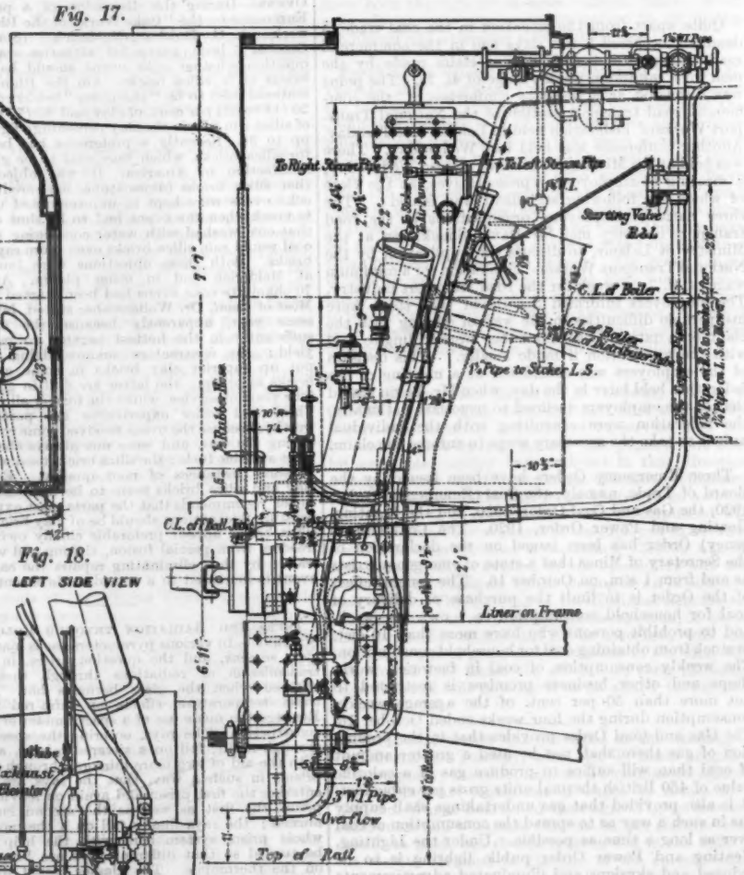
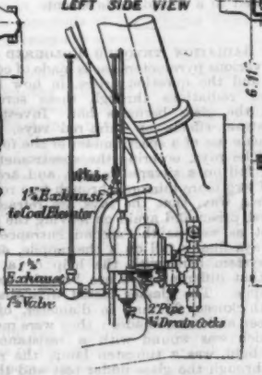


Fig. 18.

LEFT SIDE VIEW



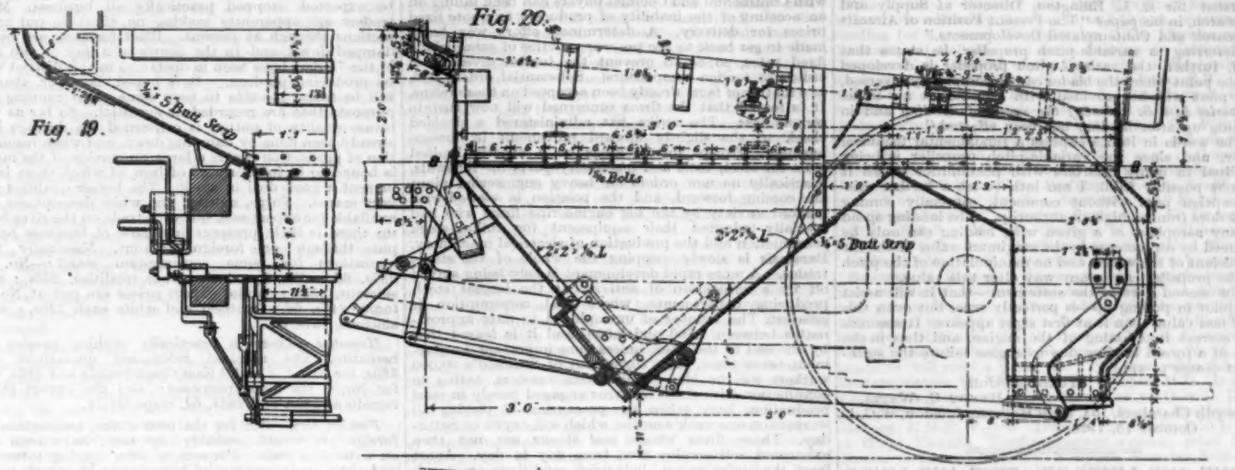
In our issue of January 16 last (page 87, vol. cix) we discussed certain features of the design of a new class of heavy locomotives brought out by the Pennsylvania Railroad for work on hill sections. We are now able, through the courtesy of Mr. J. T. Wallis, formerly general superintendent of motive power, Altoona, and now chief of motive power, Philadelphia, to give drawings, &c., of interesting points of this design.

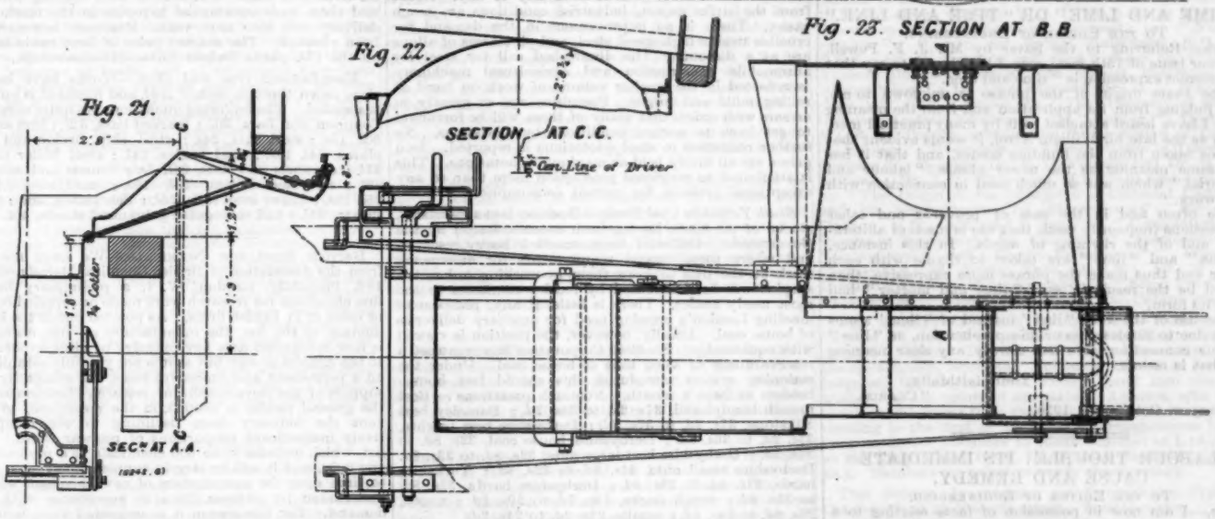
A general idea of this locomotive may be obtained from Figs. 1, 2 and 3, Plate LXIV with this week's issue of Engineering, and Fig. 15, reproduced from a photograph. The engine weighs in working order 371,800 lb., of which 342,050 lb. are on the driving wheels. The driving wheels are 62 in. in diameter and the cylinders 30½ in. by 32 in. With a boiler pressure of 250 lb. per square inch, these combine to make a very powerful machine. The boiler has tube-heating surface amounting to 4,043·9 sq. ft. and fire-box surface of 290·2 sq. ft., making a total of 4,334 sq. ft., with 1,478·9 sq. ft. of superheater surface. The grate area is 70 sq. ft. Illustrations of the boiler are given in Figs. 4 to 14, Plate LXIV.

From these figures it will be seen that the boiler has the typical Pennsylvania type of Belpaire box, with a wide grate, and the now usual combustion space obtained by pushing the tube plate forward down the barrel. The barrel is composed of three telescopic courses, slightly tapering forward, the largest being 93 in. in outside diameter. These courses are of plate 1¼ in. thick. The fire-box tapers in towards the back head, at the top, and also slightly at the bottom, as will be seen in the plan, Fig. 4. The fire-box roof slopes down considerably towards the back end. The fire-box wrapper and side plates are ⅜ in. thick. The back head is of $\frac{7}{16}$ in. steel plate. Sixteen stays are carried from the back head to brackets on the first course of the barrel close to the dome. The fire-box is of steel, the sides and crown being of ⅜-in. plate, as is also the back plate. The tube sheet and the throat sheet are ½ in. The arrangement of this part of the box will be clear from Fig. 14. Figs. 10 and 11 give details of the dome which is of pressed steel, 1⅛ in. thick. Figs. 8 and 9 show details of the patches at points to which there are outside stay attachments. The front tube plate is ½ in. thick and is shown in Fig. 12. It is stayed to the front two barrel courses by 10 diagonal stays fastened to brackets. The barrel allows of tubes 19 ft. long between tube

DETAILS OF 2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

CONSTRUCTED TO THE DESIGNS OF MR. J. T. WALLIS, CHIEF OF MOTIVE POWER, PHILADELPHIA, PA., U.S.A.





plates. There are 244 tubes of this length, 2¼ in. outside diameter, and 48 tubes 5½ in. diameter to accommodate the superheater elements. The latter are 18 ft. in length.

The grate is of the rocking finger type arranged to be rocked in four sections, with a drop section in the middle. The brick arch is supported on arch tubes. The engine is fitted with a Duplex stoker, as shown in Figs. 16 to 18, page 338, although provision for this is not shown in Figs. 1 to 14, the engine having first undergone exhaustive tests with hand-firing. The stoking apparatus comprises a coal crusher and conveyor on the tender. The conveyor is arranged below the floor of the coal bunker. It is steam driven by a single cylinder horizontal engine. The main conveyor is of the screw type working in a trough. This delivers coal to two branch conveyors which raise the coal to two openings in the fire-box back, from which points it is scattered on to the grate by steam jets. The exhaust steam from the stoker engine is turned into the elevator screw compartment and damps the coal before it is injected into the fire-box. The stoker engine makes about 48 strokes a minute. The conveyor screws are worked by racks attached to the piston rod, and a ratchet is provided so that they may be reversed in case of blocking by any obstruction, in order to clear. The stoker is reported to give a fairly level fire under all conditions, without supplementary hand-firing. Although apparently rather wasteful of fuel, except at the highest rates, it is not more so than other types, while it has advantages peculiar to itself, such as absence of obstruction at the fire door, and on the grates, and ease of operation. The stoker uses about 2 per cent. of the steam produced by the boiler. When firing at the higher rates, up to 180 lb. of fuel per square ft. of grate area the stoker shows up as economical as hand-firing, and while the machine can maintain these rates for any period prolonged hand firing on this scale would be impossible without reliefs. Figs. 19 to 23, above, show the ash pan, which is of rather unusual design owing to the height of the wheels. The main portion of the ash pan extends down between the frames in two sections, one ahead of and one behind the trailing axle (Fig. 20). The width of the fire-box, however, necessitates the upper part of the ash pan extending far over the frames. For most of its length this is of the ordinary sloping-floor design, but at the trailing wheels a pocket has to be provided for the flange (Fig. 21). This results in the bottom sloping up instead of down, and hinged doors have been provided at the outer edge, to clear these sections. The ash-pan doors under the hoppers are two in number, worked by independent levers. An air inlet, 8 in. wide, is left along the top edge of the ash pan, giving a total air inlet area under the grate of 12·7 sq. ft.

(To be continued.)

UNION PETROLEUM COMPANY, LIMITED.—According to *The South African Mining and Engineering Journal*, the Union Petroleum Company, Limited, report another discovery of petroleum a few miles distant from the first find. The second discovery is said to be quite as important as the first one, but it is added that the chief significance and value to the company of the new find lies in the fact that a line is now established between two definite points, and this line is bound to run parallel with the axis of an anticline. The locating of this anticline and its axis is thus very much facilitated, and survey work in this connection is now being proceeded with. On the completion of the geological survey the correct positions for drilling can be fixed with far greater certainty.

THE BLACKENING OF ALUMINIUM UTENSILS.—Complaints are sometimes heard that cooking utensils made of aluminium turn black even if merely used for boiling water. According to a communication, presented to the Gesellschaft für Metallkunde at their meeting last September by Dr. Czochralski, such aluminium is chemically and mechanically, as well as medically, unobjectionable. The contents of iron and silicon have certainly very little to do with the discolouration. A certain alkalinity of the water seems to avoid the trouble; too much free alkali would, of course, corrode the aluminium. A slight acidity, due to vinegar or citric acid, also prevents the blackening. On the other hand it does not appear that the blackening would not occur if the vessel in question, when used in the first instance, had served for boiling milk or fatty substances.

GLASS-METAL JOINTS.—A summary of the various means of joining glass to glass and to metals and of tests of such joints was given by E. C. McKelvy and C. S. Taylor, of the United States Bureau of Standards, in the July issue of the journal of the American Chemical Society (pages 1364 to 1377). The various methods used in the Bureau may not be of particular novelty, but the detailed instructions given and the descriptions of the valves of the needle and diaphragm types are of interest, specially for experimenters who have to handle liquefied gases and volatile liquids in apparatus that must be connected and disconnected without any change of weight. Soldered joints and fused joints are described. For joining tubes a length of about 20 mm. of the glass tube is selected which is an easy fit into the metal tube where it bears against a shoulder. The glass surface is roughened with emery and glycerol and painted with a suspension of platinum chloride in lavender oil or with a solution of the platinum chloride in alcohol and stearic acid; the platinum is burned in by the Bunsen flame. This coating is then galvanically covered with copper, nickel or gold; a strip of zinc foil is then soldered to the nickel, and the tube finally soldered into the steel tube. Fused joints can be made with the aid of the patented flux of Kraus which consists of equal parts of zinc oxide, borax and soda glass, fused in a crucible and cast into rods; when high temperatures are admissible, the flux can be omitted. Tests of joints, in which the glass had not been roughened nor platinised, also gave good results. Tin washers are used in fusing metal tubes into metal caps.

VARIABLE-PITCH PROPELLERS FOR AIRCRAFT.

To the Editor of Engineering.

Sir,—May I claim a few inches of your valuable space to comment on a statement made by Air Vice-Marshal Sir E. L. Ellington, Director of Supply and Research, in his paper "The Present Position of Aircraft Research and Contemplated Developments."

Referring to variable-pitch propeller, he states that "If, further, the variable-pitch propeller is developed to the point where the blades can be completely reversed, the pilot will be provided with an efficient air brake *to assist him in reducing the speed of landing* and in pulling up after landing has been effected."

The words in italics express a fundamental technical error, and since the variable-pitch propeller is being credited in many quarters with possibilities which it cannot possibly fulfil, I am loth to let a further misconception pass without comment, especially coming as it does from so high an authority. The landing speed of any aeroplane of a given wing loading can only be reduced by an increase in the maximum value of the lift coefficient of the wings, and no manipulation of the pitch of the propeller can in any way alter this value.

The second part of the statement—that it will assist the pilot in pulling up—is perfectly true, but even this is of less value than it at first sight appears. It assumes the correct functioning of the engine, and thus in the case of a forced landing due to engine failure the statement ceases to apply.

Yours faithfully,

Henry C. Watts.

Gwydir Chambers, 104, High Holborn, London, W.C. 1.
October 15, 1920.

"TIME AND LIME" OR "TIME AND LINE."

To the Editor of Engineering.

Sir,—Referring to the letter by Mr. J. F. Powell, in your issue of 15th inst., may I be allowed to say that the correct expression is "time and lime."

The exact origin of the phrase is unknown to me, but judging from its application and from the meaning that I have heard attached to it by many practical men, such as the late Sir William Arrol, it seems evident that it was taken from the building trades, and that it has the same meaning as the newer phrase "labour and material," which was so much used in connection with war work.

We often find in the case of proverbs and other expressions frequently used, that use is made of alliteration and of the rhyming of words. In this instance, "time" and "lime" are taken to rhyme with each other and thus make the phrase more expressive, than would be the result if, say, "time and mortar" had been its form.

The use of the word "line" instead of "lime" seems to be due to carelessness or misapprehension, as "line" in this connection does not convey any clear meaning of what is meant.

Yours faithfully,

"Clarus."

Glasgow, October 20, 1920.

LABOUR TROUBLE: ITS IMMEDIATE CAUSE AND REMEDY.

To the Editor of Engineering.

Sir,—I am now in possession of facts relating to a working agreement which has been in operation many years between a certain industrial concern and its employees. While differing in some essentials from my original proposal contained in your issue of August 13, under the above heading, I think you will find them of sufficient relative interest to warrant your allowing me to place same before "J.C.R." and any other readers who may be interested.

The facts may be summarised as follows:—

The firm in question has an agreement with the unions concerned under which it agrees to employ only union labour, and when any labour is required the unions are asked to supply it. If they cannot do so within 24 hours, the firm is entitled to find outside labour, but on the condition that such labour shall be immediately enrolled in the union.

The bulk of the employees concerned are engaged on the group piecework system, and each is thus closely interested in the results his fellow-workers achieve, so that to some extent they exercise influence over each other in keeping work moving. The firm, however, reckons out each man's share of the wages and pays it over to him.

There is one small section of the men not covered by the above arrangements and who are organised in a separate trade union which acts in many ways as a sub-contractor, *i.e.*, the firm supplies the rooms and appliances, the work is paid for at so much per piece, and the union makes its own arrangements for dealing with any increase or decrease in trade, sending more or less men as required. The union thus controls the labour and the work being paid for at so much per piece, the resultant sum is paid over to the men as a body and distributed by them as they think fit.

The experience of the firm is that by this arrangement it is not relieved from labour trouble, and questions arise such as whether the contract rate for certain work is sufficient, what increase should be given to compensate for the increased cost of living, and so on. These questions are not found to be any easier to settle with this section than with other sections of employees who are not on this system.

Yours faithfully,

October 19, 1920. "An Employer."

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The coal strike has occurred at the worst possible time so far as the heavy engineering trades are concerned. For some months past business with Continental and Colonial buyers had been falling off on account of the inability of producers to quote fixed prices for delivery. A determined effort was being made to get back to the pre-war practice of establishing fixed rates, so as to prevent the further diversion of orders to foreign competitors. Substantial orders had, as a matter of fact, already been accepted on these terms. It is feared that the firms concerned will now sustain serious loss. The strike has administered a decided check to the slightly upward movement in foreign business. Except for bookings on a strictly limited scale for steel, tools and machinery parts for renewals, practically no new orders for heavy engineering plant are coming forward, and the position is viewed with marked anxiety by the big engineering firms who had specially adapted their equipment for rolling-stock construction and the production of electrical machinery. Paralysis is slowly gripping the whole of the staple trades. A more rapid development is only being staved off by a suspension of activity at the largest steel-producing departments, where coal consumption is greatest. The number of unemployed to date approximates between 7,000 and 8,000, and it is feared that by the end of the week, unless some important development takes place, fully 30,000 out of Sheffield's 90,000 workers will be idle. Engineering masters, acting in conjunction with those concerns engaged purely in steel production, have taken the precaution of placing all workers on one week's notice, which will expire on Saturday. Those firms whose coal stocks are not then exhausted will employ men from day to day. Apart from the strike aspect, industrial conditions are much easier. There is no improvement in the demand for crucible steel or high-speed steel, and all classes of alloys are at a discount. The diminished call for steel for automobile construction and agricultural machinery is reflected in the smaller volume of work on hand at rolling mills and forges. Foundries are so greatly in arrears with orders that many of them will be fortunate to get back to normal conditions by Christmas. No further reduction in steel quotations is reported. Iron prices are all firmly held at maximum quotations. This is attributed to restricted production more than to any exceptional pressure for current consumption.

South Yorkshire Coal Trade.—Business is at a standstill, stocks of all kinds having been commandeered by the Government. Collieries have amassed heavy reserves, and where these exceed requirements for emergency work at the pits to keep them in working order, the surplus will be distributed by local committees to the most needy trades. There is little, if any, prospect of meeting London's pressing need for auxiliary deliveries of house coal. Locally, however, the position is viewed with equanimity. Sheffield Corporation has organised a reserve dump of 8,000 tons of house coal. Under the rationing system introduced, this should last householders at least a month. Nominal quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.* Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

Steel Furniture.—On the 14th inst. Messrs. Ronco, Limited, celebrated the coming of age of their firm by opening new factories at Romford, Essex, for the manufacture of steel office furniture and equipment. They have expended over 80,000*l.* on the new factories and plant, and at present over 50 per cent. of the workers are ex-service men.

The Nottingham Electricity Supply.—Two schemes were recently put forward for the Nottingham electricity supply, one on behalf of the Corporation of Nottingham, and the other on behalf of the Derbyshire and Nottingham Electric Power Company, and the merits of both schemes were gone into very fully. The case for the corporation was presented by the town clerk (Mr. W. J. Board); his efforts proved successful, and the decision of the Electricity Commissioners, which was received during September, approved the corporation scheme. A site has been acquired for the new station which has considerable frontage to the River Trent. The scheme provides for a super-power station to be proceeded with in three sections, the total cost being about 1,500,000*l.* It is intended at present to proceed only with the first section, at a cost of about 850,000*l.* Under the terms of the Electricity Commissioners' Report, the Nottingham Corporation have to give a supply of power in bulk to the Derbyshire and Nottingham Electric Power Company, as and when required, on terms to be agreed. When the necessity for this arises, the second section, and possibly the third, would then be proceeded with. The site consists of nine fields, having a total area of about 80 acres. No time is being lost with regard to setting to work, and it is fully anticipated that when this station is completed Nottingham will be in a position to give an unlimited supply of current, at as low a rate as prevails in any other manufacturing centre in the country. It is hoped that current will be available from the first section within two years from now. There are, in Nottingham, several sites available for new works, many of which adjoin either railways or waterways, whilst some are available to both.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron market is stagnant, the miners strike having, as was to be expected, stopped practically all business. Most traders are apparently making no effort to put transactions through at present. Blast furnaces are being damped down, and in the course of a day or two few of the 71 that have been in operation in this district will be producing pig-iron. It is hoped, however, that it will be found possible to keep some plant running for purposes that are regarded as essential. So far as the future quality of output is concerned the damage has already been done by damping down, and when resumption of production occurs a large proportion of the make is bound to be inferior kind of iron, of which there is at present a good deal in stock. The better qualities are very scarce. Forge, mottled and white descriptions are available for export sale, but with trade on the river held up there is little prospect just now of business being put through on foreign account. Nominally the quotations for home consumption stand:—No. 1, 237*s.* 6*d.*; No. 3 and the lower qualities, 225*s.*; and silicious, 255*s.*; whilst export prices are put at No. 4 forge, 247*s.* 6*d.*; mottled and white each 230*s.*; and silicious, 237*s.* 6*d.*

Hematite.—There is practically nothing passing in hematite. The nominal recognised quotations are 260*s.* for Nos. 1, 2 and 3 East Coast brands and 262*s.* 6*d.* for No. 1 for home purposes; and the export rates remain at 280*s.* and 282*s.* 6*d.* respectively.

Foreign Ore.—But for the coal strike, transaction in foreign ore would probably, by now, have been on an extensive scale. Consumers were coming forward, and there were substantial inquiries in the market for delivery well into next year. Business, however, has been checked. The market price of best rubio is 50*s.* on the 17*s.* parity freight Bilbao-Middlesbrough.

Manufactured Iron and Steel.—Works have had to close down through lack of coal, and business is entirely suspended. The following quotations are quite nominal: Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.*; soft steel billets, 23*l.* 10*s.*; hard steel billets, 25*l.* 10*s.*; heavy steel rails, 25*l.*; fish plates, 30*l.*; black sheets, 35*l.*; and corrugated galvanised sheets, 40*l.*

British Research Chemicals.—We have received from the Association of British Chemical Manufacturers, 166, Piccadilly, London, W. 1, a preliminary list of fine chemicals for research work made or supplied by one or more of 21 British firms. As pointed out in the introduction to the list, the manufacture of fine chemicals is now recognised as a key industry of vital importance to the Empire in war, but as it is not yet fully established on a permanent and successful basis, the sympathy and support of the Government, of research chemists and of the general public is needed, in the meantime, to prevent the industry from declining to the comparatively insignificant proportions of pre-war times. The list, which includes some 500 chemicals, is a preliminary one only, and it will be largely supplemented from time to time since the manufacture of new chemicals will be undertaken by various firms in accordance with the demand. For this reason it is suggested that inquiries for chemicals not mentioned in the present list should be made to the association at the address given above. The association will then make every endeavour to meet requirements. We recommend the matter to the careful attention of our readers who are users of fine chemicals, since the importance of rendering the country as far as possible, independent of foreign sources of supplies of these essential products cannot be too strongly urged.

Steel Specifications.—We have received a number of leaflets from Messrs. Vickers, Limited, Broadway, Westminster, S.W. 1, giving specifications of special steels which they make. These range through straight carbon steels to tungsten, chrome and nickel steels for special purposes. The carbon steels dealt with are three in number, and range from mild steel of 0·25 per cent. to 0·45 per cent. for general axles, shafts, &c., up to the firm's "A" steel with carbon between 0·45 per cent. and 55 per cent., and a maximum strength of 45 tons to 60 tons. Another pamphlet gives the specification for 33 per cent. nickel steel; another deals with chrome spring steel. Three others detail the specifications for mild, medium and hard nickel chrome steel, the third having a maximum strength of 60 tons to 70 tons and Brinell hardness (treated) of 269 to 341. Air-hardening and oil-hardening nickel-chrome steels are described in other specifications, the latter being suitable for gears, with a tensile strength of 100 tons to 125 tons and Brinell hardness (treated) of 429 to 555. Two further specifications refer to case-hardening nickel steels of 2 per cent. and 3½ per cent., and case-hardening mild steel, while another deals with local hardening by the oxy-acetylene flame method. The range of tool steels made by Messrs. Vickers runs from carbon steels for ordinary tools, hammers, punches, swages, &c., up to cutter steel, and through three grades of chrome steel to tungsten and vanadium steels. One of the chromium steels is employed in the production of cast milling cutters which only require finishing by grinding. Other sections deal with steels for locomotive crank axles, tyres, straight axles, and so on. The information both as regards tests, treatment, &c., of all these steels is clearly set forth in an interesting manner.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Trade Position.—The depressed state which has characterised the general markets during the past week or two is now considerably worse owing to the coal strike. Up till the very last it was thought that a way out of the difficulty would be found and that work in the mines would not be stopped, but the result of the ballot on the "datum line" being so overwhelmingly against acceptance, operations in the industry ceased on Saturday. Already the shortage of fuel has caused many establishments to suspend a goodly number of their workers, and thousands of men and women are now idle. The consumption of fuel in the iron and steel works in Lanarkshire alone amounts to so great a tonnage that it will not take many more days to bring all of them to a complete standstill. The machine shops and engineering sections depend largely for their power on electric current, and as the principal company supplying same can run for a number of weeks these branches will be able to carry on for some time. The various shipyards will soon feel the pinch, as the supply of plates has practically ceased, and when stocks have been used up, the yards will have to cease operations. Many of the textile firms will be able to continue for about a couple of weeks, but if the strike is not over by that time the whole trade of the country will be dislocated.

Scotch Steel Trade.—There is now little doing in the Scotch steel industry, and producing plants, which are not already stopped down, are likely to be out of operation within a few days owing to the lack of fuel. Business during the past week has been very slow, and the uncertainty prevailing was the cause of poor inquiry. The demand for deliveries of ship plates and sections against existing contracts was rather pressing for fear of the steel-producing works being knocked off, and now that they are being gradually stopped the shipbuilding establishments can only carry on for a limited time. The makers of black sheets are being affected like all the other branches of trade, and as consumers have been unable to accumulate supplies they also will be very soon out of action. The export side of the steel trade has been considerably reduced through the coal crisis. Prices in general have been maintained, but an easier tendency was noticeable towards the end of last week.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland have recently been experiencing a very steady demand for bar iron, and the output has been on a large scale. New contracts have not been very numerous of late, and now that the coal strike has intervened fresh bookings show a decided decrease.

Scotch Pig-Iron Trade.—The home demand for pig-iron has continued steady and deliveries have been eagerly sought by consumers. Prices are quoted without change locally, but export quotations have been shaded to induce more overseas business. Everything has now been brought to a standstill through the miners' strike, and furnaces are being damped down or blown out. When a re-start takes place there will be the usual scramble for deliveries. The export price for foundry iron is from 15*l.* 10*s.* to 16*l.* per ton, but nothing can be shipped meantime.

INSTITUTE OF INDUSTRIAL ADMINISTRATION.—This Institute announces that an address on "The Industrial Question" is expected to be delivered by Lord Haldane, O.M., at a meeting at 8 p.m. to-morrow, the 23rd inst., in the Central Hall, Westminster, when Sir Lynden Macassey, K.B.E., K.C., will take the chair.

THE PROBLEM OF THE HELICOPTER.—We are informed that a paper on the subject of the helicopter will be read before the Royal Aeronautical Society at a meeting to be held at the Royal Society of Arts, John-street, Adelphi, London, W.C.2, on Thursday, November 18, at 5 p.m. The author of the paper is the French consulting engineer, M. Louis Damblanc, who has recently been carrying out some experiments with a full-size direct-lift machine under the auspices of the French Government. The importance of developing a machine of this type is such as to give considerable interest to the paper, and it is likely to cause extensive discussion among aeronautical experts.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—At the first meeting of the session, held on the 13th inst., the new president, Sir Henry Fowler, K.B.E., was inducted into the chair by the retiring president, Mr. Thomas Clarkson. Sir Henry delivered an address on the subject of the relationship between employers and labour (see page 511 *ante*). The practice of holding informal dinners before meetings promises to be very successful, and will, we understand, form a regular feature of the work of the session. The annual dinner of the Institution will take place on the 27th inst. It can now be definitely stated that the report of the Steel Research Committee on the 10 standard automobile steels published in Report No. 75 of the British Engineering Standards Association, will be issued at the end of this month. The value of the report will undoubtedly be enhanced by the opportunity which will be afforded for its discussion by the paper which is to be given by Mr. J. H. S. Dickenson before the Institution on November 10. Persons desiring to obtain a copy of the report, with a view to taking part in the discussion are asked to make early application to the Secretary of the Institution, at 28, Victoria-street, London, S.W. 1. The price of the report is 31*s.* 6*d.*, carriage and packing 1*s.* 6*d.* extra.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Business in the coal trade is at a complete standstill and likely to remain so as long as the coal strike continues. When it became known that the miners had definitely decided that the suspended strike notices should become operative from Monday last, the sailing of all British ships was suspended, also the loading of foreign vessels. The loading of British tonnage was continued, but every vessel was placed under the orders of the Government, while even partly-laden foreign ships were turned from under the tips and bunkers refused to light vessels. Fully and partly-loaded and light foreign ships were allowed to proceed to sea, but those without bunkers on board were tied up at the buoys. The serious effect of these restrictions will be realised from the fact that out of 427 vessels in the South Wales Docks 254 were British owned and 173 foreign, and it is practically certain that the greater proportion of the latter will be unable to sail because of lack of bunkers. All the coal standing at the docks and colliery sidings has been commandeered by the Government, and instructions have been issued that none is to be removed without the sanction of the local Coal and Coke Supplies Committee. Already thousands of workers at the docks have been thrown out of employment, and as the stocks of coal become enhausted so the ranks of the unemployed will become larger. Exports of coal to foreign countries in the week prior to the commencement of the strike amounted to 279,000 tons, of which 195,000 tons went to France, 22,000 tons to Italy, 4,500 tons to South America, 17,000 tons to Spain, 10,000 tons to Portugal, 5,000 tons to Greece, 15,000 tons to British coaling stations, and 10,000 tons to other countries. The average f.o.b. price of large coal shipped at Cardiff in September was 97*s.* 2*d.* per ton, compared with 75*s.* 9*d.* in January, at Newport 99*s.* 4*d.* against 68*s.* 5*d.*, at Swansea 88*s.* 4*d.* against 68*s.*, and at Port Talbot 94*s.* 9*d.* against 80*s.* 1½*d.* Small coals shipped from Cardiff averaged 80*s.* 2*d.* compared with 59*s.* 4*d.*, at Newport 65*s.* against 48*s.* 2*d.*, at Swansea 53*s.* 2*d.* against 42*s.* 10*d.*, and at Port Talbot 63*s.* 9*d.* against 48*s.* 9*d.* It is estimated that the output of coal for the whole country in the quarter ended September totalled 59,000,000 tons, compared with 54,144,000 tons in the previous quarter, and that a credit balance of 16,750,000*l.* is shown for the quarter, against 7,908,000*l.* in the June quarter.

The Iron and Steel Trades.—It is anticipated that by the end of the week 30,000 hands will be rendered idle as a consequence of the miners' strike. Apart from this there is a poor demand for steel and tin plates, and it is reported that, at Birmingham, Welsh plates have been offered down to 42*s.* 6*d.* per basis box, though at Swansea 44*s.* 6*d.* to 46*s.* 6*d.* is nominally quoted. In the galvanised sheet section, 24-gauge corrugateds, in bundles, are down to 38*l.* to 39*l.* per ton.

EX-BRITISH WESTINGHOUSE ASSOCIATION.—The third annual reunion dinner will take place in the Holborn Restaurant on Friday, March 18, at 6.30 p.m. Invitations to members will be sent later. Inquiries should be addressed to the Hon. Secretary, Mr. L. S. Richardson, 14, Sydney-road, Richmond, Surrey.

THE INDUSTRIAL LEAGUE AND COUNCIL.—A fortnight ago, Mr. H. Hirst, member of the Industrial League and Council, and managing director of the General Electric Company, Limited, invited to a conference at his residence, "Foxhill," Earley, near Reading, a number of prominent Members of Parliament, works representatives, and representatives of trade societies, to take part during the week-end in a discussion on the Industrial position and indulge in friendly conversations, with the object of arriving at a complete understanding on the best means to further British trade in all its branches. The conference was successful in every way, and it is to be hoped that other, similar meetings, will be arranged for throughout the country.

EARTH-DAM REGULATING RESERVOIR AT OTTMACHAU.—For the purpose of raising the water level in the Upper Oder from 1·4 m. to at least 1·7 m. (4 ft. 7 in. to 5 ft. 7 in.) the Prussian Government has decided to create an artificial lake from the waters of the Glatzer Neisse, one of the tributaries of the Oder, and to close the Ottmachau valley by a dam, nearly 20 m. (65 ft.) in height. Such regulating reservoirs are fairly numerous in Germany, but big dams have so far not been built in earth in Germany, though huge earth dams have been erected in America on the Panama Canal and elsewhere. Geologically the valley to be closed consists of tertiary clays and sands, overlain by 8 m. of diluvial and alluvial formations; the tertiary clay is not impermeable to water. To prevent any underwashing of the dam by the water of the lake to be created, a sheet-piling cut off is to be drawn on the inside of the dam 10·5 m. (34 ft.) down into the tertiary. On the top of this piling an inclined layer of clay up to 3 m. (10 ft.) in thickness is to be rammed down; road metal and gravel will be piled over this clay and the batter of 1 in 3 up to 1 in 1·5 is to be secured by paving. The main mass of the dam will be filled up in sand and earth. The width of the base is to be 143·5 m. (471 ft.), the width of the flat crown 5 m. (16½ ft.); a wall is to be erected on the top on the inner side of the dam. The water level is to be kept 5 m. below the crown for three years to allow consolidation of the ground; finally the water is to come up within 2 m. (6½ ft. of the crown). Grass is to be grown on the outer slope which will be drained by furrows, longitudinal and transverse, up to 4 m. (13 ft.) in depth. The full capacity of the reservoir will be 260,000,000 cub. m. (about 9,100 million cub. ft.).

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 22, at 6 p.m., at the Institution, Storey's Gate, S.W. Presidential address by Captain H. Riall Sankey, C.B.

THE FARADAY SOCIETY AND THE PHYSICAL SOCIETY OF LONDON.—Monday, October 25, at 2.30 p.m., combined meeting for a general discussion on "The Physics and Chemistry of Colloids and their Bearing on Industrial Questions," in the Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W. 1; Sir Robert Hadfield, Bart., F.R.S., President of the Faraday Society, will take the chair at 2.30 p.m. precisely; Professor Sir William Bragg, K.B.E., F.R.S., President of the Physical Society of London, will preside over the discussion. 2.30 p.m. to 4 p.m.: General introduction, "A Short Survey of the Physics and Chemistry of Colloids," by Professor Dr. The Svedberg of the University of Upsala; discussion on "Emulsions and Emulsification"; opener, Professor F. G. Donnan, C.B.E., F.R.S.; Mr. W. Clayton, M.Sc., will read a paper on "Emulsion Problems in Margarine Manufacture"; Mr. S. S. Bhatnagar will read a paper on "Reversal of Phases in Emulsions and Precipitation of Suspensoids by Electrolysis—An Analogy." 4 p.m. to 4.30 p.m.: Interval for tea, which will be provided. 4.30 p.m. to 6.15 p.m.: Discussion on "Physical Properties of Elastic Gels"; Openers, Mr. E. Hatschek, F.Inst.P., and Professor H. R. Procter, D.Sc.; Mr. S. C. Bradford will read a paper on "The Reversible Sol-gel Transformation"; Dr. J. C. W. Barratt, M.D., D.Sc., will read a paper on "The Structure of Gels." Discussion on "Glass and Pyrosols"; Opener, Sir Herbert Jackson, K.B.E., F.R.S. Interval for dinner, 6.30 p.m., at Hotel Victoria, Northumberland-avenue, price 12*s.* [Notice to be sent to Mr. F. S. Spiers, Faraday Society, 10, Essex-street, Strand, W.C. 2.] 8 p.m. to 10 p.m. Discussion on Non-Aqueous Systems: (*a*) "Nitrocellulose"; Opener, Sir Robert Robertson, K.B.E., F.R.S.; Mr. F. Sproxton will read a paper on "Non-Aqueous Colloid Systems, with Special Reference to Nitrocellulose"; Dr. Guy Barr and Mr. L. L. Bircumshaw will read a paper on "The Viscosity of some Cellulose Acetate Solutions." (*b*) "Rubber"; Opener, Mr. B. D. Porritt, speaking on "The Action of Light on Rubber." Discussion on "Precipitation in Disperse Systems"; Openers, Dr. R. C. Tolman and Dr. R. S. Willows; Mr. J. N. Mukherjee, M.Sc., will read a paper on "The Origin of the Charge of a Colloidal Particle and its Neutralisation by Electrolytes"; Mr. W. Clayton, M.Sc., will read a paper on "Coagulation of Inorganic Suspensions by Emulsions." Discussion on "Cataphoresis and Electro-Endosmose"; Opener, Professor A. W. Porter, D.Sc., F.R.S.; Dr. W. R. Ormandy, F.I.C., will read a paper on "Some Practical Applications of Electro-Endosmose and Cataphoresis."

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, October 27, at 2.30 p.m., Meeting in the Mappin Hall, Applied Science Department, The University, St. George's-square, Sheffield. Following the initial formal business, the meeting will resolve itself into one of welcome to the returned delegates to America, who will speak on "Lessons from the Visit to America." As the meeting is the first of the session, arrangements have been made for members to lunch together at 1.15 p.m. at the King's Head Hotel, High-street, Sheffield (charge 4*s.*). Members are asked to notify the secretary.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 29, at 39, Victoria-street. Social evening.

THE DE HAVILLAND AIRCRAFT COMPANY, LIMITED.—On several occasions we have urged the importance to the aviation industry of the future of making every effort to prevent the dispersal of designing staffs collected and trained during the war, and we therefore welcome any means by which this desirable end may be achieved without direct assistance from the State. During the war some 30 per cent. of the aeroplanes built in this country and in the United States were de Havilland machines of various types, and the reputation for performance and reliability attained by these machines is ample evidence of the skill and experience of their designers and constructors. The Aircraft Manufacturing Company, Limited, Hendon, at whose works all D.H. machines were designed and where many of them were constructed, upon recently coming under new control decided to discontinue the design and manufacture of aircraft. In these circumstances it seemed likely that the design staff would be disbanded, but we understand that the necessity for this has been obviated by the formation of a new private company having the title at the head of this paragraph. The new company, which has acquired the lease of the land and buildings at the Stag-lane Aerodrome, Edgware, Middlesex, and will carry on the design and manufacture of D.H. machines, is staffed by members of the late design and managerial departments of the Aircraft Manufacturing Co., Ltd., and its three directors are Mr. A. E. Turner, Captain G. de Havilland and Mr. C. E. Walker; the two latter were, respectively, technical director and chief engineer of the old company. Even at the present time it is anticipated that both the designing and constructional departments of the new company will be well occupied, and in connection with the development of civil aviation the experience of the former should be a valuable asset to the nation. In our issue of August 20 last, on page 238, we illustrated and described the "Airco 18," which is a good example of the post-war production of the staff we are referring to, and this machine, we understand, has given excellent results on the commercial cross-channel services between London and the Continent.

THE SAURER TIP-WAGON AT THE COMMERCIAL MOTOR EXHIBITION.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME ADOLPHE SAURER, ARBON, SWITZERLAND.

(*For Description, see Page* 535.)

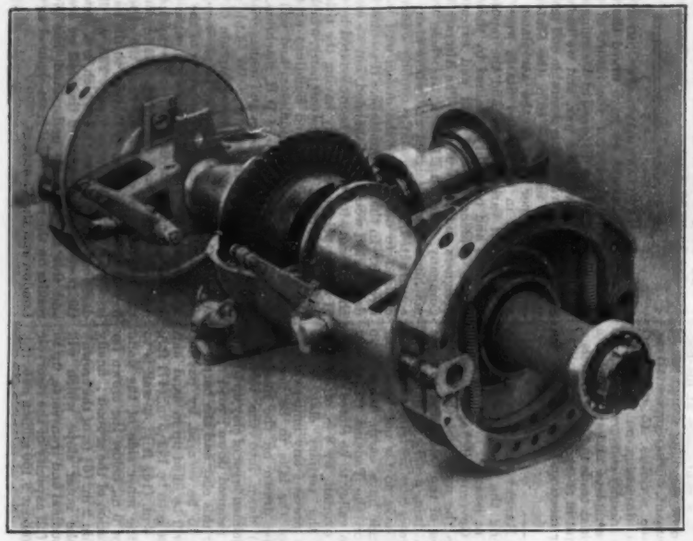


Fig. 3. The Back Axle.

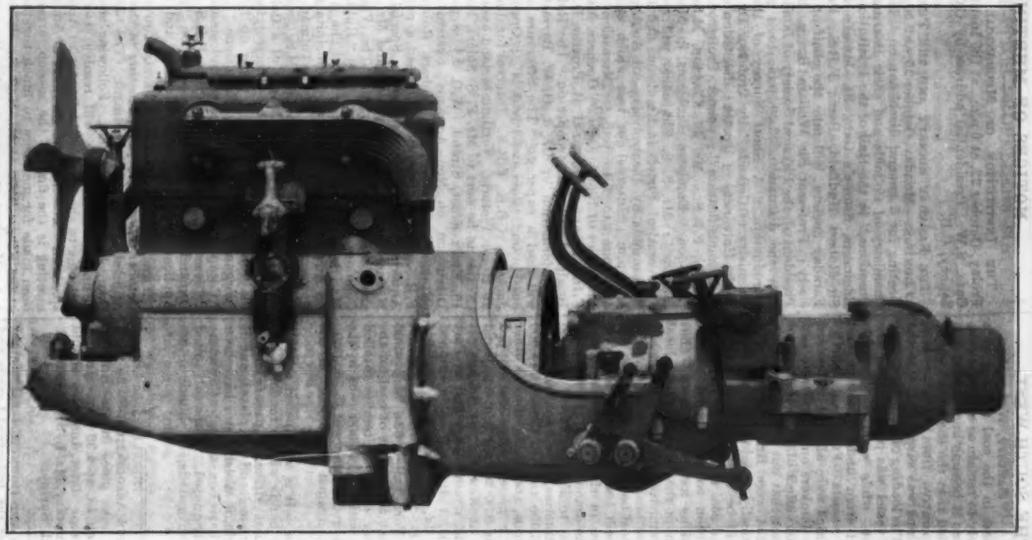


Fig. 4. The Engine and Gear-Box Unit.

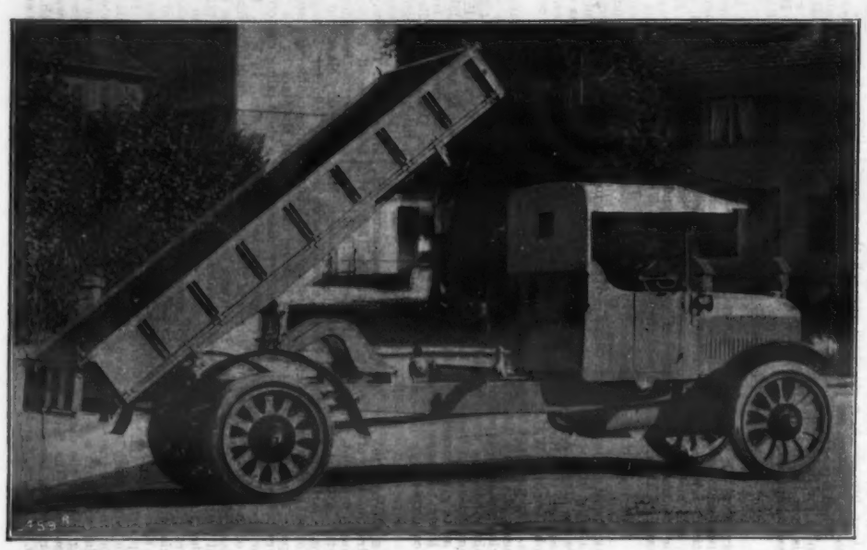


Fig. 5. The Vehicle Tipping at Back.

Fig. 6. The Vehicle Tipping at Side.

2-10-0-TYPE LOCOMOTIVE; PENNSYLVANIA RAILROAD.

CONSTRUCTED TO THE DESIGNS OF MR. J. T. WALLIS, CHIEF OF MOTIVE POWER, PHILADELPHIA, PA., U.S.A.

(For Description, see Page 538.)

Fig. 1.

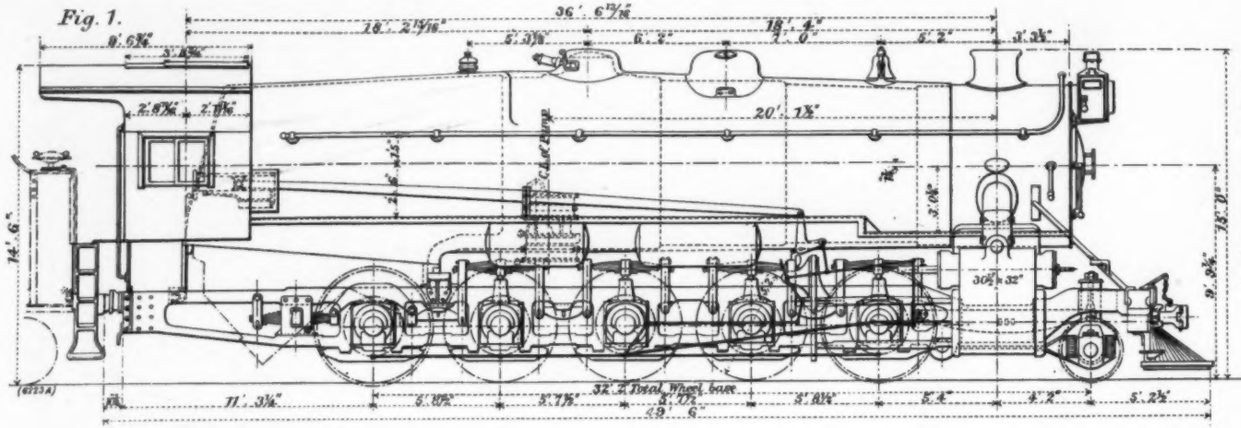
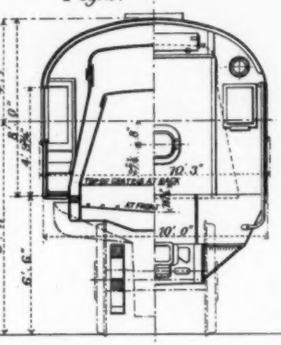


Fig. 2.



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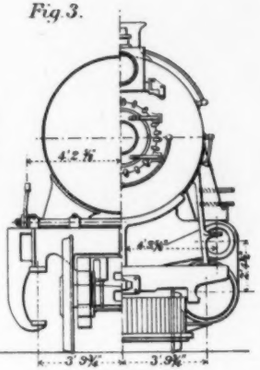

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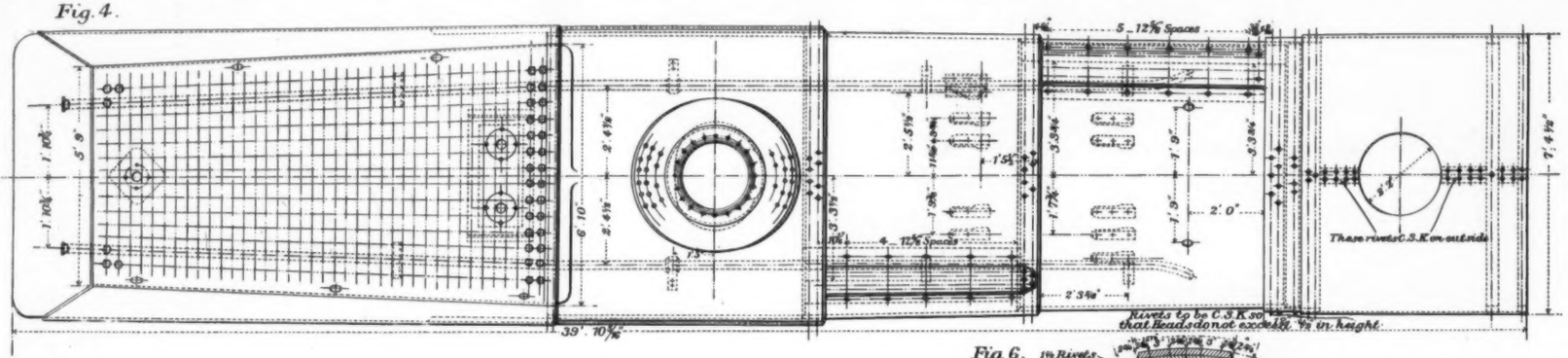

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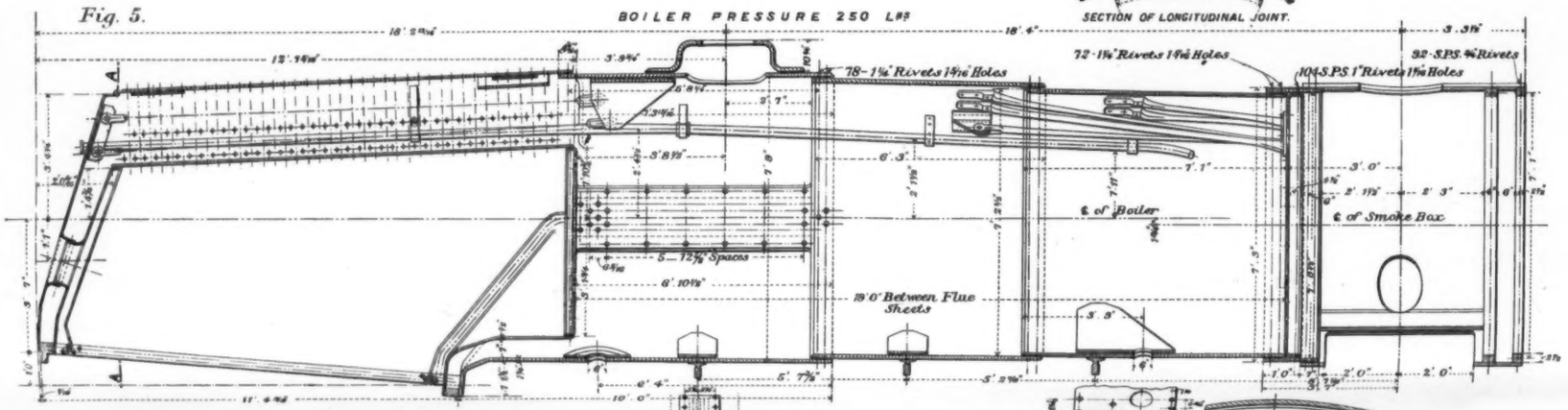
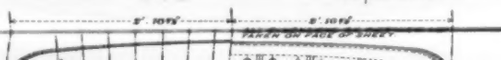

BOILER PRESSURE 250 Lbs
78 - 1 1/8" Rivets 1 3/16" Holes
72 - 1 1/8" Rivets 1 3/16" Holes
104 S.P.S. 1" Rivets 1 1/16" Holes
32 - S.P.S. 1" Rivets
5 - 12 5/8 Spaces
19' 0" Between Flue Sheets
℄ of Boiler
℄ of Smoke Box

Fig. 7.



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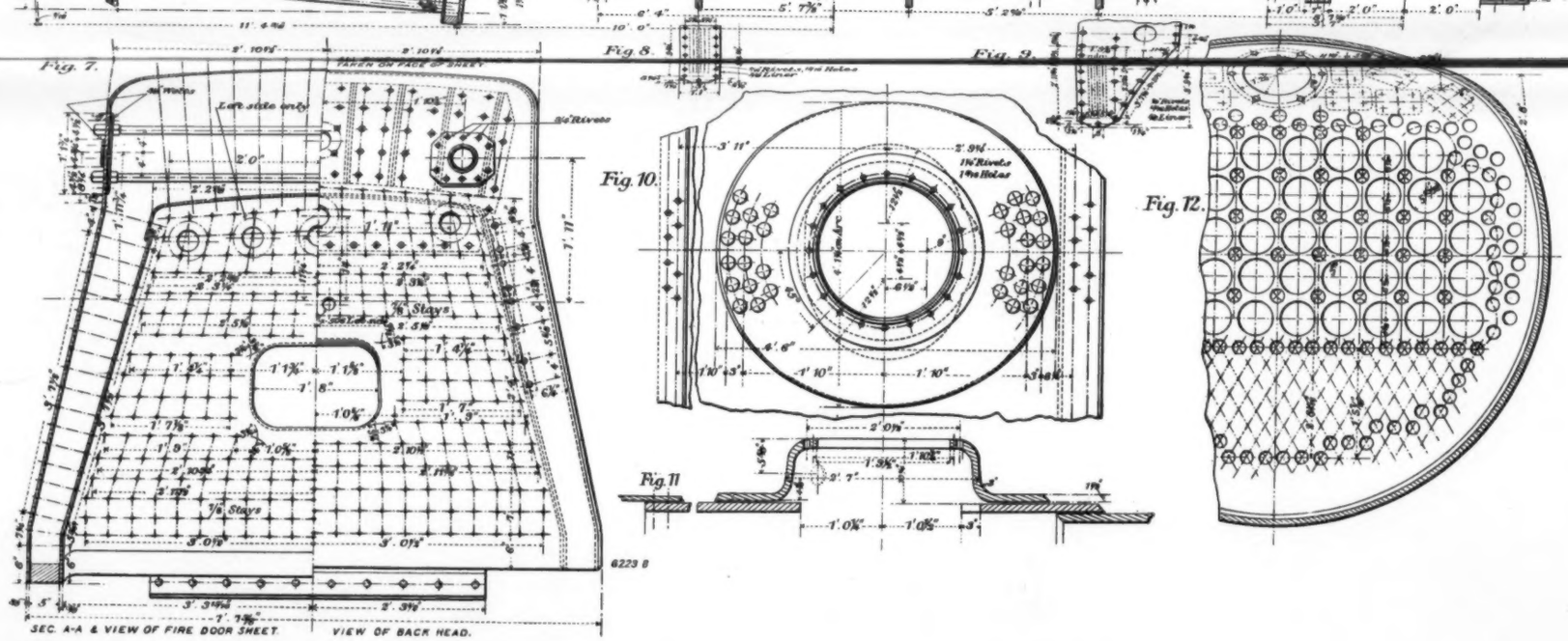
Fig. 7.
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SEC. A-A & VIEW OF FIRE DOOR SHEET.
VIEW OF BACK HEAD.
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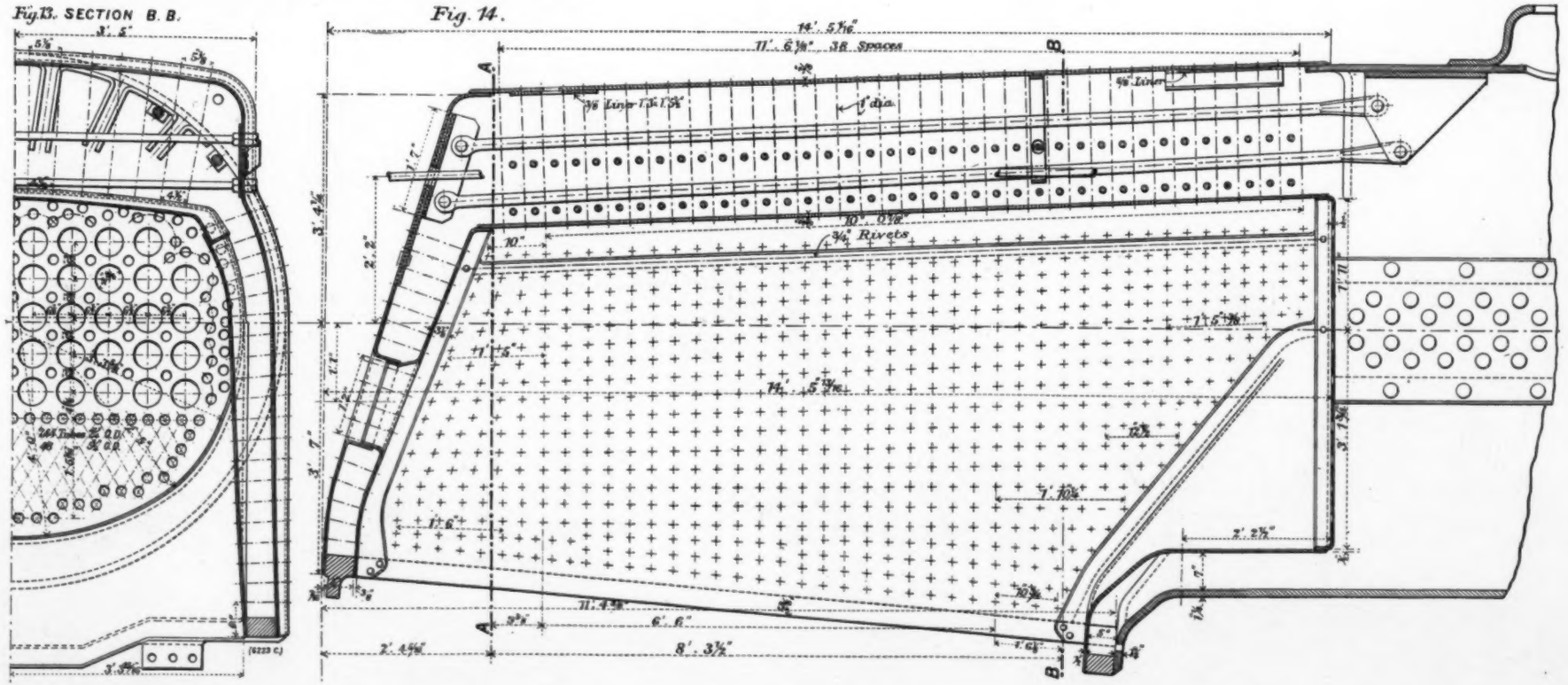
Fig. 13. SECTION B. B.
Fig. 14.
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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 541.

ENGINEERING.

FRIDAY, OCTOBER 22, 1920.

ALTERNATIVE FUELS.

THE mass of conflicting views which was heard at the Fuel Section meetings of the Imperial Motor Transport Conference on Monday and Tuesday of this week, was sufficient to bewilder the most earnest student of the prospects of the future of the mechanical transport industry. This Conference, which has most opportunely been held at Olympia during the Commercial Vehicle Exhibition, by the courtesy of the Society of Motor Manufacturers and Traders, has been attended by well-known authorities on the subject, and the divergence of opinion in many directions is really remarkable.

In the first place, we had the Secretary to the Royal Commission on Oil Fuel of 1913, assuring us that petrol would be unobtainable by the private user in two years' time from now. In juxtaposition to this Sir John Cadman said that two-thirds of the earth contained rocks which were worth exploring for oil, and only a fraction of the world's surface had so far been touched. Then we had the statement that alcohol could be economically obtained from cultivated crops. This was traversed, and it was asserted that by far the best way to produce it was to make use of refuse material from present crops. Again it was stated that a new and satisfactory denaturant would probably be introduced shortly in England, while another speaker, who had as much claim as anybody to be an authority on this point, said that no satisfactory and economical denaturant had so far been found, though there was promise of one in a certain direction. It was not all disagreement, however. Everyone concurred in the opinion that the consumption of petrol had overtaken the supply, and it was also agreed that it would be about two years before alcohol, if the manufacture were put in hand at once, could be marketed on a scale to make it a useful fuel and a paying proposition.

The consumption of petrol in the United Kingdom is estimated for this year, we understand, at 300,000,000 gallons. Let us just review some of the points brought out in these recent discussions on substitutes or alternative fuels. There is very little question of meeting the demand by getting still more out of the original oil. Already the distillation limits are on the wide side for good spirit to be produced. If more is extracted we merely rob Peter to pay Paul, and all sorts of people, from painters to admirals, will be up in arms at once with the complaint that their own particular share of constituent of the crude oil has been tampered with. The painter now uses just that fractional spirit which we are told comes next in the list of constituents to be given to the motorists, if the range is widened. That would disturb present markets, would lead to buying back at increased cost and would, therefore, make matters worse. The latest ships in the Navy are designed for fuel oil of a certain specification, with combustion spaces in the boiler cut down to $\frac{1}{10}$ cub. ft. per horse-power, for using oil of this quality. If constituents are withdrawn for the benefit of the motor industry, our ships will fail to attain to their designed speed; all who feel pride in our Empire would regret such a result as the consequence of an effort to bolster up an industry which has developed into a state of unequilibrium. It appears to be useless, therefore, to endeavour to get more from existing oil supplies. In fact, this seemed to be the sum and substance of Mr. Harold Moore's paper read before the Conference, and pending the proof or otherwise of Sir John Cadman's optimism it behoves us to do what we can to bring about a state promising improvement.

If we are thrown back on alcohol, we find plenty of promise, but it is to be feared little else. The acreage in the tropics which, properly cultivated, would supply us with all the alcohol needed to replace petrol in the United Kingdom is said by Dr. Ormandy to be about the size of Kent. But this proposition, and others involving special cultivation, necessitate extra labour, the solution of transport problems, and many other points. It is not seriously suggested that crops should be grown in England for the purpose, and while if this fuel is manufactured abroad for transport to England, the cost of this service might make it prohibitive. The solution may appear to lie between the two. It might be possible to produce alcohol locally in Africa, India, and elsewhere, or near enough to those countries, for the supply to be feasible economically, and so to release petrol for England. But there we are faced with the likelihood of the United States very shortly absorbing practically all the petrol production of the world, and as we control only a fraction of it the release of petrol by the use, say, of alcohol throughout India, would not benefit us to any extent.

We are next faced, supposing one of the promised supplies to materialise, by other problems. Dr. Ormandy's paper showed that, unless a distilling plant abroad was to be excessively loaded with capital charges, its work must be more or less uniform throughout the year, and the plant must not be designed to cope with a huge seasonal rush of material. This means both storage of material and product, the latter to allow sufficient to accumulate for transit in bulk on economical lines. Supposing a supply to be forthcoming what will be the oil companies' attitude towards it? Will they assist in the transport and distribution, or will they regard the fuel as a rival? At present we are glad to know that the oil people are encouraging the movement, and it seems that they alone can offer facilities on a sufficiently big scale for the scheme to be brought to fruition. In South Africa, we understand, that alcohol is locally produced in fairly large quantities, owing to the high price of petrol, and the presence of a suitable waste material. It may be feasible thus to supply small self-contained markets, but the case of England is very different.

With petrol practically universal here, it would complicate things considerably if we developed special engines and then found that our selected fuel was not obtainable at many of the points we had to run to. This, of course, is the designer's and user's trouble. We hear a deal about modifying the machine to meet some other fuel, but though this may mean cheap working for a time, it may even so be only at the cost of a prohibitive amount of inconvenience, and so lead to no benefit. On the other hand, there are probably markets abroad which, if studied with special reference to local fuels, would bring to our lorry builders quite a lot of business, so far absolutely untouched. That is another point, and is worth consideration, and at the same time would ease the world petrol situation, but not necessarily our own. The advantage of the present standardisation is that a lorry or car transferred through work, or sale, from one area to another in our country can always obtain fuel to suit it. There are about seven qualities of petrol stocked by retail dealers here, but any of them can be used at a pinch. The perfecting of an engine for a totally different fuel would necessitate additional small stocks all over the place, unless the change-over is so complete that the petrol vehicle practically goes out of existence.

It seems to us that in order to conserve the

petrol available for, say, America, since carriage cost would bulk least if sold in that country, it would be in the oil owners' interests to encourage the conversion to alcohol here, even by selling the latter fuel at a loss for some years. However, we might, unless the Government were very much on the alert, then find ourselves worse entangled than before, and faced with artificially high prices for the new fuel. It certainly seems that if alcohol is to come it must come on a scale large enough to bring ample supplies to our shores. People will not adopt it if there is to be trouble in getting it, or they will postpone doing so hoping that something better may develop, and in the meantime the small industry may easily die. Sweden, we believe, now manufactures enough from waste wood to render petrol importation unnecessary. Other countries are embarking on similar lines. Within the Empire there are schemes said to be quite promising afoot, but the matter has not yet got very far. Sir Charles Bedford has pinned his faith to the use of rice straw in India, a waste product available in districts where water carriage is cheap, and other facilities offer—this with the object of producing a cheap fuel. Others again want no cheap fuel at present, for fear of rate cutting by the petrol industry which would quickly ruin the alcohol firms. So there is little prospect of getting a cheap fuel at home, though it may be possible locally abroad, and we may be forced to look even further than alcohol.

This fuel, however, evidently occupies most attention in the motoring world at the moment. We are told that most of the Governments are now sympathetic on the matter, and that regulations are being revised to improve the situation with regard to the use of this fuel in Great Britain. That it can be used, best in the form of mixtures perhaps, has been amply demonstrated on the Continent. Recent experiments conducted by the London General Omnibus Company on a large scale at considerable cost in meeting the existing regulations, support a similar conclusion. These experiments formed the subject of a paper read before the Conference by Mr. G. J. Shave, who was in charge of the work. The figures given are too extensive to quote and the paper itself will repay perusal.

The main point on which the Government does not yet seem able to go as far as the alcohol school would wish, is that of denaturing. The Government at present insists that denaturing should be done here. That means that a spirit denatured at the time of manufacture abroad would have to be treated again here. It is said this would rule alcohol out of court. How necessary is some universal regulation on this point was noticed by a speaker who pictured the case of an aeroplane landing in several countries on a long trip, and having to denature the fuel it carried on each occasion. This, of course, would be absurd, but it is what the present regulations amount to.

When we come to other fuels, the position is not much clearer. Several suggestions are made with regard to gasification. Mr. John Wells, who did a lot of valuable work during the war in Egypt when that country was short both of coal and oil, by developing a producer which would use cotton stalks and other refuse, read a paper before the Conference suggesting that gas used on the internal combustion or external system might offer a solution in many parts. We are all aware that experiments with producers and with stored gas have been made on road vehicles, but at present the authorities in this country are not satisfied that the developments are up to the requisite standard for general adoption. The stationary producer devised by Mr. Wells has the advantage that it can be used as a gas producer with charcoal fuel, or as a charcoal producer when fuel is plentiful, and little or no work is to be done. This frequently happens, of course, after gathering in a crop, and then, when the hands are free, charcoal may be made and stored, the same producer being used at other times for making gas for use either under boilers, or in gas engines. This system adopted in Egypt was of immense value to that country when fuel was absolutely unobtainable. Dr. Ormandy states that if the whole of the cotton sticks of the United States crop could be converted into charcoal it would represent fuel equivalent to about two-thirds the petrol production of the world. Refuse may, therefore, be utilised to advantage locally in this manner. It is interesting to note Mr. Wells' success with these producers, for it may be remembered that Professor A. Chatterton, of Madras, worked for a long time on a charcoal gas producer for small lift irrigation schemes, but met with a good many difficulties. Mr. Wells does not enter into the question of the application of his system to such small portable units as are necessary for motor transport, but the matter is worth attention, if only from the point of view of turning over stationary practice to such a system for the relief of the oils and spirits.

Derivatives from coal, either gaseous or liquid, are other possible supplies, providing our coal industry does not die out. Even if the process of mining it becomes impossible, we may yet find the means of applying some system of gasifying in the seam as suggested by Sir William Ramsay. At the present moment such a system would afford immense relief. The low-temperature carbonisation school has not yet perfected its methods which promise some help in this matter, and though steadily pursuing its object cannot yet claim commercial success. Another combination is suggested by Sir Arthur Duckham in a paper read before the Institution of Petroleum Technologists on Tuesday last. Sir Arthur proposes vertical retorts combined with a water gas producer for the complete gasification of the coal with the recovery of the maximum amount of volatiles in liquid form with a minimum amount of cracking. This process, conducted at the pits, he considers would relieve the fuel oil situation, and the distribution of gas would relieve the railways of much coal traffic. This, to be of service to motor transport, would, of course, either involve the use of gas in the engine, or of a heavy fuel oil, and would again call for modification therefore, of the motor.

FACTORY CONDITIONS IN 1919.

It is evident that many paragraphs in the report* on Factories and Workshops for the year 1919 must have been penned several months since. The writer of these enlarges, for example, on the smoothness with which the change over from war to peace conditions was effected, and on the unprecedented demand for commodities of all kinds, so that "manufacturers generally have booked enough orders to keep them fully occupied for a very long time to come." Recent experience has unfortunately afforded much evidence that the view here taken was unduly sanguine, and that though the world is badly in need of goods it will contrive to do without them unless they can be obtained at a reasonable rate of exchange. The South American farmer, for example, is not willing to supply more tons of wheat or meat than formerly in exchange for, say, an agricultural engine or a motor car, and will contrive accordingly, as the professional classes have done in this country, to do without many things that in pre-war days would have been purchased as a matter of course. In short, the serious depression with which we are threatened can only be stayed by a very substantial reduction in labour costs. In this connection there is at any rate one cheering symptom, and that is the rapid rate at which "workshops" are being converted into "factories." The distinction between the two is that the "factory" has mechanical power, whilst in the workshop tools and machines are all operated by muscle, the most expensive of all prime movers. According to the report the number of factories has increased by 12,396 since 1914, whilst the number of workshops has diminished by 8,060. In America, it will be remembered, the horse-power installed per operative is something like three times as great as in this country, a circumstance which is largely responsible for that combination of large outputs and low labour costs which makes the United States such a successful competitor in the world's markets, in spite of the high rates of wages paid. For the rest her success depends upon her economical use of skilled labour, which is not, as is too frequently the case in this country, set to monotonous repetition work which, as we discovered during the war, any ordinary girl can learn to perform with a few weeks' training. The short-sighted, and indeed unintelligent, fashion in which our trades unions regard this matter is a serious handicap both to raising the status of the skilled man, and to that increase in production which is a necessity if we are to recover our former position of relative prosperity.

From the report it appears that the introduction of the eight-hour day has in some cases led to no loss of production, whilst leading to great improvement in the matter of time-keeping, which must tend to the more regular and profitable conduct of the factory. The trades in which output has not suffered are mainly those involving great exertion or constant alertness on the part of the workman, but where production depends almost entirely on the speed of the machinery as in spinning, it is stated that the fall in output has been nearly in proportion to the reduction in hours. There is, however, some indirect evidence that this falling-off can be eliminated by a suitable increase in the so-called "non-productive" section of the staff. Thus at a silk spinning and weaving factory when the hours of work were reduced from 49 to 44 per week the output actually rose. In this case careful records were kept of each machine and worker, and any deficiency in individual output closely investigated. This often brought to light slight defects in the machinery and also demonstrated the fact that temperature had a considerable influence on production. Moreover, it was found that certain workers were not fitted to the work on which they were engaged, but made good when transferred to other duties. This plan of fitting the job to the workman instead of the workman to the job appears to have been first systematically practised by that remarkable genius the late F. W. Taylor, who is reported to have said that whilst he had no use for any but a first class operative he had yet to meet with the man who did not prove first class at some kind of work.

The transformation of workshops into factories, to which reference has been made above, has been greatly facilitated by the introduction of electric power. At the same time, however, it is not the small workshop merely that is adopting the electric drive, but the mill owners in the woollen and cotton districts are now clamouring for supplies of electric energy, and are, it is stated, somewhat aggrieved when their desires cannot instantly be satisfied. This item is of very great interest in view of the undeveloped state, electrically speaking, of the great Lancashire manufacturing area. This unfortunate condition originated in a desire to save Lancashire from the Trusts, with the result that where the so called Trust was given a fairly free hand as in the North East Coast area, energy* was supplied by the Trust at an average cost of less than ½*d.* per unit, the charges made in Lancashire, where the supply is mainly in the hands of public authorities averaged 1½*d.* per unit.

Nemesis has apparently at length overtaken the lack of intelligence and insight shown by the ruling powers in the Lancashire area, and it will be difficult to supply the energy now demanded, at any reasonable cost, in view of the large sums unwisely invested in relatively small local power stations. Something, the report states, has been effected by linking up, but the margin thus secured has been rapidly overtaken.

The report states that safety and sanitation declined during the war years, but there would seem to be a certain discrepancy between this observation and the report for 1918, in which attention was drawn to the fact that, in spite of bad lighting, the general employment of inexperienced workers and the dangerous character of some of the war industries the actual death roll was in some districts even lower than in pre-war times. However this may be, the report observes that lost ground is being rapidly recovered, and in spite of the great increase in trade the number of fatal accidents was not much in excess of the figure for 1914, being 1,385 as compared with 1,287. Including all accidents the return shows lower figures than in 1914, the number reported being 124,632, as compared with 158,585. In view of the growing tendency to report as

* *Annual Report of the Chief Inspector of Factories and Workshops for the Year* 1919. H.M. Stationery Office. 1920. [Price 1s. 6d. net.]

* Interim Report on Electric Power Supply in Great Britain, 1918.

accidents very trivial mishaps this would be a remarkable result, but doubt is expressed as to whether the returns for last year are reliable, as inquiry has disclosed numerous cases in which the returns are incomplete. In 1918 there were 1,579 fatalities and 164,000 reported accidents. In last year's report attention was called to the good results which had followed in certain cases from the establishment of safety committees, elected by the workmen to co-operate with the management in diminishing industrial dangers. Unfortunately little further progress is to be reported. The extraordinary suspicions with which many men have been brought by long continued propaganda to regard their employers, is well illustrated by the term "whitewash committee" applied to the safety committee by a man in the northern area, who had persuaded himself that the institution of this committee was intended to relieve the firm of liability for such accidents as might occur. This is, of course, legally impossible, and it is to be hoped that the workman in question will himself be appointed some day to a safety committee and thus learn by first hand experience that managers and employers, particularly in the case of large works, are sincerely desirous of diminishing industrial risks. Case after case is reported in which employers have spontaneously gone far beyond the requirements of the department. Thus, following one of those particularly horrible accidents in which men are caught by plain smooth revolving shafts, one works proprietor had the whole of his shafting surrounded by metal tubing. In certain cases special safety inspectors have been appointed. The results have been good, and have led to substantial reductions in the claims made under the Workmen's Compensation Act, but the safety committee has incidental advantages in that it brings together management and workmen in voluntary association towards a common end, and gives an opportunity for friendly relations between the two. Moreover, a safety committee can take, without creating offence, more drastic action than is open to the management. Thus in certain East End factories the Committee has dismissed men who refused to comply with their requirements. The workman is often accused, and in many cases with justice, of utilising much of his native ingenuity and skill to diminish output, but the recklessness with which guards are removed owing to their interfering somewhat with the ease of running a machine is evidence that the policy in question is far from universal. Constant inspection is necessary to ensure that fencing and guards shall be maintained. Many accidents are the results of ignorance, and the report insists on the necessity for adequately warning lads entering a trade against such dangers as may be associated with it. The example chosen to illustrate the need for this is, however, hardly happy. In shipyards it is observed that quite a number of lads are injured or killed by falls from staging, and complaint is made that these lads of from 14 to 16 years of age were not warned of the danger. Really, however, if a youth of 14 does not realise without special instruction that a fall of 30 ft. to 40 ft. is likely to be disastrous, his proper destination would seem to be rather Earlswood than the banks of the Clyde or Tyne. The system of mutual insurance against accident risks is said to be proving very effective in promoting the adoption of safety devices. Thus, the Federation of Master Cotton Spinners maintains an inspector to visit all the mills concerned and to see that the fencing and other safeguards are adequately maintained.

It is very regrettable to note that the disgusting character of the sanitary conveniences at so many of our factories has been but little bettered. Lancashire is a particularly bad offender in this respect, but equally vile conditions were discovered at a Somersetshire creamery. The London area leads England in this regard, and, if the provinces persist in maintaining their nauseating record, Parliament may well be called upon to make the London standard compulsory. We have led the world in sanitary invention and improvement, and it is very discreditable to us that the old proverb concerning the cobbler's child being ill shod should find a parallel in the sanitary equipments of our factories. Ultimately, it is to be hoped that the growing self-respect of our workmen will insist also on the provision of properly equipped and maintained lavatories where they can wash and change before leaving for home. This practice is common in America, and attempts have been made to introduce it here in many cases with most unsatisfactory results. The plan of providing accommodation permitting of this is, however, spreading, and many of the new factories in the Midlands are said to be excellently equipped in this regard. Proper supervision is, however, a first essential, and failures in the past are largely attributable to the absence of this.

In general, of course, it is the small factories which err both as regards the adoption of safety appliances and in respect of sanitary matters. It is, however, often difficult to take action. Many of these employers control but two or three hands as in the Sheffield tenement factories, some of which are incapable of improvement, whilst to condemn them would deprive the very hard working and struggling tenant of his means of livelihood as other premises are, under present conditions, unavailable. In the case of large firms controlled by the "wealthy capitalist" who forms the stock subject for denunciation by the street corner orator, it is common to find that the provisions made for the well-being of the workmen are in excess of the statutory requirements. It is these large and prosperous firms which are introducing "engineering" methods into the cutlery trade, thereby greatly diminishing the dangers of the industry. The old grindstone, the occasion of so much disease and of many serious accidents, is being largely replaced in the lighter cutlery trade by artificial stones of emery, corundum or carborundum, such wheels being in practically universal use for the grinding of scissors, razors and pocket knives. On the other hand they have not proved successful as yet for grinding table knives and files, being less "kind" than the natural stones. The latter are liable to burst with disastrous results, and are difficult to guard adequately. The report notes that large stones are more liable to fail than small ones even when the surface speed is the same. The general introduction of drop forging has reduced occupational disease because it has largely diminished the amount of grinding necessary, as the articles are forged closer to the finished shape and dimensions. This replacement of hand labour by machinery is so often deprecated by well meaning but unscientific writers that it is well to call attention to the improvements its employment makes possible in the hygienic conditions of our industries. Unfortunately, popular writers, instead of applying to engineers for information as to the actual effects of machinery on the life of the worker, commonly prefer, like the mediæval school man, to infer their results, and consequently get as hopelessly at sea as their predecessors in the same school of thought who explained the pumping of water by the assumption that nature abhorred a vacuum.

The dangers of dust, particularly silica dust, have been increasingly recognised of late years. It is even suggested that the prevalence of phthisis amongst printers is attributable to the large proportion of silica which has been discovered in the dust collected from composing rooms. The use of suction fans to draw off the dust at the very place where it originates is steadily increasing, and it is to be hoped will soon be more general since respirators are disliked by the workmen and are often discarded. In one factory an electric vacuum cleaner is being used to clean down all walls, shelves, &c., weekly. This method of removing dust is ideal, as none of it escapes when disturbed into the atmosphere of the workroom. The report states that marked progress has been made in the introduction of welfare conditions and measures either legal or voluntary. The interest taken by the workers is specially marked in the less organised trades, which is what would have been anticipated. Indeed, it is to be feared that certain labour leaders would be inclined to discourage the movement, as tending to foster a spirit of comradeship between masters and men. This new spirit is said to be specially marked in the case of young employers returned from the war. Canteens and mess-rooms are being provided in increasing numbers, and the engineering trades are singled out for special mention in this connection.

The replacement of women engaged during the war by men is now pretty well complete. In the engineering trades it is probably absolutely so, but the fact that engineering works are being started to be operated wholly by female labour gives hope that the experience gained of woman's capabilities in this matter will not be wholly wasted. It may be mentioned that women are stated to have also established an excellent record as crane operators, but have now been retained only at the New Holland Docks in Lincolnshire.

THE SHIPBUILDING INDUSTRY.

The fact that the United Kingdom is now rapidly regaining the position in the world of shipbuilding she held in pre-war times, is indicated by the statistics just issued by Lloyd's Register for the quarter ended on the 30th ultimo. Before the war the merchant tonnage under construction in this country usually exceeded the total building in all other countries of the world, and although this is not the case at the present time, the tonnage building abroad only exceeds the United Kingdom tonnage under construction by about 103,000 tons. At the end of the September quarter the vessels building in this country numbered 961, and their total gross tonnage amounted to 3,731,098, the latter figure showing an increase of 153,000 tons over that for the previous quarter, and of 914,000 tons over that for a year ago; the increase during the year thus amounts to over 32 per cent, and in comparison with the figure for September, 1913, the increase is over 90 per cent. A considerable number of large vessels are now in hand, although the individual tonnage in no case exceeds 25,000. There are now building 64 vessels of 10,000 tons and over, 57 vessels of 12,000 tons and over, 25 vessels of 15,000 tons and over, and 4 vessels of over 20,000 tons and under 25,000 tons.

The true criterion of shipbuilding activity is, however, the tonnage launched, and in this respect the September quarter is less satisfactory than the previous one. The vessels launched numbered 144 and had an aggregate tonnage of 483,057, while the corresponding figures for the June quarter were 165 vessels launched with a total tonnage of 523,303. The September quarter tonnage launched is thus 40,246 tons less than that launched in the June quarter, the reduction amounting to nearly 8 per cent.

Over one-third of the total tonnage now in hand is building on the Clyde, Glasgow and Greenock between them accounting for 272 vessels with a total tonnage of 1,327,593; the latter figure shows an increase of 66,816 tons (5·3 per cent.) in comparison with the June quarter. At Newcastle 128 vessels, making 660,726 tons, are now under construction, the increase during the quarter, in this case, amounting to 10,557 tons, or under 2 per cent. Belfast also shows an increase of about 4 per cent. in the work in hand, the vessels now building there numbering 53 and having a total tonnage of 352,730. The figures for Sunderland and Middlesbrough are 68 vessels (322,098 tons) and 56 vessels (256,503 tons) respectively, but at the former port the work has fallen off during the quarter to the extent of 7,405 tons, or about 2¼ per cent.; Middlesbrough, on the other hand, shows an increase of 7,343 tons (nearly 3 per cent.). The only other districts with more than 100,000 tons of shipping under construction are Liverpool with 70 ships, making 144,840 tons; Barrow with 16 ships, making 133,389 tons; and Hartlepool with 23 ships, making 107,640 tons. The respective increases for these three districts are 20·2 per cent., 1·4 per cent. and 8·9 per cent.

With regard to the tonnage building abroad, the most noticeable feature is the decline in the tonnage building in the United States, where there are now only 312 vessels, with an aggregate gross tonnage of 1,772,193 in hand, as compared with 767 vessels and 3,470,748 tons, which were the figures for the corresponding quarter of last year. The United States tonnage building now is thus but little more than half the amount in hand in September, 1919. Holland now takes second place among foreign ship-

building nations, the ships in hand in the Dutch yards numbering 165 and having an aggregate tonnage of 423,400; the latter figure shows an increase of over 47 per cent. in comparison with that for the same time last year. Italy (which now includes Trieste) and France, both show large increases in shipbuilding activity, the former country being now engaged in building 156 vessels of 365,313 tons in the aggregate, while the latter is building 89 ships with a total tonnage of 292,608. The figures for Italy and France in September, 1919, were 285,928 tons (108 vessels) and 174,736 tons (64 vessels), respectively, so that the increase in the case of Italy amounts to nearly 28 per cent., while in France the increase has been over 67 per cent. Japan, on the other hand, is building less than she was a year ago, the figures for that country now being 262,407 tons (72 vessels), as compared with 299,600 tons (64 vessels) in September of last year. Shipbuilding in the British Dominions has also declined during the year ended September 30 last, the work in hand being now only 213,894 tons (89 ships), while a year ago it was 308,465 tons (174 vessels); the decrease in this case amounts to over 27 per cent. The only other countries with more than 100,000 tons of shipping under construction are Sweden and Denmark, the figures for these countries being 121,849 tons (69 vessels) and 116,063 tons (62 vessels), respectively. Other foreign countries between them are building 130 ships with an aggregate tonnage of 266,346, so that, with the figures given above, the total number of vessels building abroad comes to 1,144 and the total gross tonnage is 3,834,073. This latter figure is less by 1,397,736 tons than that for September of last year, the difference, which amounts to nearly 27 per cent., being due almost entirely to the reduction of the work in hand in the United States.

It may be interesting to note, in conclusion, that of the vessels now under construction, 114, having a total gross tonnage of 796,060, are intended for carrying oil in bulk. The United States is building 79 of these ships, making 545,302 tons together, while the United Kingdom has 32 tank steamers, with a total tonnage of 232,758, in hand; three more tank steamers, making 18,000 tons together, are building in other foreign countries. Only five small steamers are being constructed of reinforced concrete in the United Kingdom, their total tonnage amounting to 2,354. The number building abroad of this material is also comparatively insignificant and amounts to only 11 vessels of 24,069 tons together. It is, perhaps, hardly necessary to remind our readers that, in the above statistics, gross tonnage is given in all cases, and that vessels of less than 100 gross tons are not considered.

THE TRANSPORT OFFICER.

With the materialisation of the Institute of Transport, the transport officer, whether he belong to railways, steamship lines, or other means of communication, is beginning to plume himself and congratulate himself on the importance of his calling. There is no harm in this since people who take pride in the standing of their vocation will probably work to maintain its high level. The electrical man once had an absolutely new subject to place before the world, and it will be remembered at first rather overdid the effort to convince us that he was essential to our being. He has, it is true, become so in the course of time. The mechanical man has been on the whole more retiring, yet there is a good deal of truth in the claim that he alone is a vital necessity to the modern world. He runs our railways for us, with the assistance, some may say, of the permanent-way department; but the latter is not indispensable and the mechanical man can conduct transport without rails. Of course, the thought at once turns to roads, but take away his roads and he will still haul for you across country or through the air. And, all said and done, who is more important to the community than the designer and maker of machine tools on which we are dependent for the manufacture of the machines on the products of which in turn our life now depends from the time we are brought into the world right to the day when a motor carries us to our last resting place. He stands behind the civil or electrical engineer, and helps them out of their difficulties.

Lord Ashfield, in his presidential address to the Institute of Transport on Monday last, gave pride of place to the transport man. This, of course, was somewhat natural in view of the audience he was addressing. He pointed out that as soon as people ceased to be nomadic transport became a factor essential to existence, and that civilisation was most advanced in those nations in which transport was most developed. But if transport has assisted in civilisation, it must also—and the mechanical engineer has to share in this—shoulder the responsibility of making war possible on the scale which we have so recently witnessed. Lord Ashfield shows that the stupendous figures of the men engaged in the recent conflict, so far outnumbering anything dreamt of before, were the direct result of mechanical transport in its various forms. It may be said that it was this which won the war for us. It was certainly an engineer's war and a war of transport. But it was transport which made the German rushes dangerous, and from beginning to end the big blows were always stopped, or at least punctuated, by pauses required to reorganise this essential service. Thus while we acknowledge our indebtedness to this industry in the peaceful tenor of its way, it must share some of the responsibility for the last conflagration in the world being on such an unprecedented scale. It is to be hoped that, while we may remain efficiently prepared for eventualities, the bulk of our attention may be centered in the future on the further peaceful development of the world's civilisation by means of transport, and to enable this industry to be of the maximum benefit to the world at large, as Lord Ashfield demonstrates, it must be controlled by the right kind of men. It is this question which really occupies the greater part of the address to which we have referred.

A good many years ago we pleaded for the broader education of railway officials, pointing out that the departmental system then so rigidly adhered to, produced men, with certain outstanding exceptions, with too narrow an outlook upon life to have the best possible combination of characteristics for the higher posts. We welcomed at that time the tendency shown here and in America to give various grades the opportunity of a wider education on the broader issues of the economics underlying operation, and have always considered such courses as those conducted on railway subjects at the London School of Economics to have been of immense benefit in this direction. Lord Ashfield now carries us rather further. Not long since it was our habit here for everybody to keep all his information to himself. There was no interchange of ideas. It was easier to cross the Atlantic and talk over things with strangers on the other side than it was to discuss them with your next door neighbour. In fact, some twenty years ago it became the fashion to go to the United States and then come home and tell how much better they did things over there, when often the talkers did not know really what was being done in this country. Fortunately those times are past. We visit each other at home as well as our friends abroad, and with the Institution of Transport as the happy medium, we ought to be in a position to derive practical results from the more thorough discussion thus rendered possible. The widening of the transport man's views is part of the Institute's excuse for existence.

For some time it has been the custom on some systems to give promising officials experience by transferring them temporarily to some other department. This is almost essential if the broader view is to be developed. It also makes it possible to discover any special aptitude a man may have for duty in some particular direction. Lord Ashfield suggests that this idea might be pushed to the length of arranging for the interchange of officials between different systems, and there is little doubt that the interchange of ideas thus brought about would result in much good. It would certainly prevent the men who have to be relied upon in the future, getting into the grooves which can hardly help developing in a business which is simply allowed to expand upon accepted lines. Whether the scheme is feasible or not will be for the Institute to decide. The principle has often been accepted in part in the case of the general managers of our railways. On several occasions men from other lines have been appointed to such posts, but as a rule, with the exception perhaps also of the position of locomotive superintendent, the idea has not often been carried beyond this. If in the changed conditions under which the railways are now operating, such interchange of officials can be arranged through the auspices of the Institute of Transport, that body will have made a very notable and promising start in its career, and we may look for the production of a grade of operating officials a good deal in advance of that which the old system of rigid departmental training, often coupled with seniority, brought as a rule to the more prominent positions.

THE COMMERCIAL MOTOR EXHIBITION.

Taking a general review of the Commercial Motor Exhibition which opened at Olympia on the 15th inst., we have three types of ordinary road vehicle to deal with, the steam, petrol and electric. The latter has, of course, only a limited employment, as it is not suitable for long-distance work, but it is extremely interesting to note that after a very considerable experience of goods carriage on the ordinary road, these three types should still be in common use on a large scale, no one of them having yet asserted its dominance over the others. No doubt to a certain extent the varying conditions to be satisfied account for the various types, as, for instance, steam can hardly be used where cleanliness is essential, but it still remains a fact that all these three forms of motive power are being used on a large scale for heavy work of essentially the same nature, and it is as yet impossible to tell which of them will ultimately come into the most general use for heavy goods carriage.

The electric vehicle has only a limited range, but within that range has many theoretical advantages, as there is no doubt that it is cheaper to generate power on a large scale, as can be done in a central generating station, than to do so on the vehicle. There is, of course, a loss in the charging and discharging the storage batteries, but this probably is not so great as the extra cost of generating the power on the vehicle. Within its range electric power should, therefore, have a distinct field, as it has the advantage in cleanliness.

Steam has the advantage of burning a cheap fuel, which is of very considerable importance in these days of high petrol prices. The weight of the power plant is, however, greater per horse-power than that of the internal-combustion engine, and it is difficult to make a satisfactory steamer on a small scale. Hence it appears only to be used for the heaviest class of vehicle. It seems also to have the disadvantage that it is difficult for the drivers to keep anything like as clean as on the internal-combustion vehicle, and some of the types practically require two men to drive.

The internal-combustion vehicle has the disadvantage of using at present an expensive fuel, and it is considered by many people to cost more than the steamer for upkeep. It has, however, the advantage of cleanliness, and probably of speed, while it is also easy to control, and will run a long distance without renewing the supply of either fuel or water.

As we have said, time alone can tell which of these types will eventually prove the most successful, and the final verdict may depend on the varying prices of different fuels. A considerable cheapening of petrol, or some equivalent of petrol, would alter the situation very considerably, as might also a considerable cheapening of coal. At present prices the only alteration at all likely to affect the relative fuel costs is the possibility of the gas producer being made a success on the internal-combustion lorry, as this would at once reduce its fuel costs to considerably below those of a steam vehicle. With regard to the upkeep costs theoretically the internal-combustion vehicle should not be greater than the steam, as there are considerably fewer parts and joints under pressure. There is considerable room for improvement in the ordinary internal-combustion vehicle in this respect, and with greater experience upkeep costs should be considerably reduced. A very interesting feature of the present

situation is that some firms which started making steam lorries are now exclusively making the internal-combustion type, while on the other hand many new firms are coming into the market with steam-driven vehicles.

Taking the variations in steam practice we have two main types. The one follows, generally speaking, traction engine practice with locomotive type boiler and engine on the top. The engine is usually compound and with two speeds. Then there is another type with the engine underneath the vehicle and usually a vertical boiler of some kind, often water tube. This type generally has a simple engine and uses superheated steam. The "over-type," i.e., traction engine type, usually has link motion and slide or piston valve, while the "under-type" often has poppet valves. Many representatives of both types are shown at the present exhibition, and there are certain compromises between the two systems. The under-type appears, however, to have gained ground considerably of recent years, and this is rather curious, for it was the earliest type of steamer and at one time almost disappeared, the over-type becoming almost universal. It does not seem quite clear why some of the points should not be applicable to both under and over-types. Thus the question of superheating and compounding does not seem to have anything to do with the question of over and under-type, and if either of these points is an advantage in one type there seems no reason why it should not be an advantage to both. Similarly the over-type usually has central pivot steering, while the under-type has Ackerman. There seems no reason why the same steering should not be the best for both.

In transmission, again, the under-type usually has a direct chain drive with a moderate gear, and a very large slow-running engine, while the over-type has two speeds with a drive through a countershaft and a much faster running engine. The under-type engine is necessarily totally enclosed while the over-type is generally open. It is very curious that the chain is almost universal as the final drive for the steam vehicles, while in the petrol vehicle the very strong tendency is to give up the chain in favour of some form of gear or worm drive. Generally speaking, the steam vehicles do not show any very great novelties. Stamped connecting and eccentric rods are used by more than one firm, as also loco type boilers with round fire-boxes. Pressed steel frames are also being introduced for the over-type lorry. Otherwise novelties appear to be in matters of small detail. The same may be said of the steam tractor, which is really a small traction engine with the exception that it is now generally fitted with rubber tyres. It is remarkable that superheating should be so little in evidence in the over-type engine and the small traction engine. One firm even which used to make a speciality of superheating with this type is now showing engines without superheating. Seeing that superheating appears to be a thorough success in the under-type lorry, there certainly, as we have said, does not seem any reason why it should not be a distinct advantage in the over-type. One point of considerable interest is the fact that plain bearings are practically universal on the steam vehicles for all parts. As it appears to be generally admitted that the cost of upkeep of a steam vehicle is low compared with most petrol vehicles, this is worth noting.

Coming now to the petrol vehicles, we find two distinct classes exhibited. In the first place a great many firms are showing vehicles of practically the types which were used during the war. As no alterations were allowed to be made to the design of any of the standard makes of vehicles used by the Army during the war, except in small matters of detail, the design of these vehicles is now some six or more years old. Granting that the design is quite satisfactory, there is, of course, no reason to change it, and it may be presumed that these firms are satisfied that their designs are satisfactory with such small modifications as they have made. On the other hand, there are firms who consider that with the experience of the war something much better than their old models can be produced and, who accordingly, show quite new, designs, in some cases of a very original nature. Other firms are sticking to their old models in the 3-ton size, which was the one made for the Army, while they have introduced new patterns for lighter loads. Taking the general design, the greatest difference of opinion appears to be as to the method of driving the back wheels. On the whole, the chain drive appears to be going out. True there are still some chain-driven lorries shown, and these often of makes which have proved themselves thoroughly satisfactory, but the proportion of chain-driven machines is very small, and several makers who used to be identified with chains are now showing live axle machines. Of the latter there are several types, namely: (1) Worm drive, the worm usually being at the top; (2) Double reduction in the differential casing, usually by a bevel driving a countershaft with spur gear to back axle; (3) Bevel gear to a countershaft carrying the differential, with pinion and internal gear to back wheels; (4) Direct bevel drive. There are also a number of special drives. Of these the worm and the direct bevel are the simplest and presumably the cheapest to make, as the internal gear and the double reduction involve an extra shaft with the necessary bearings, &c.

So far the direct bevel gear has hardly been used in heavy vehicles, as it has been thought that it was not practicable to make it satisfactory with the necessary reduction between the engine and the back wheels. In a light car there is no difficulty about this, and the direct bevel has become practically universal, but in a car the reduction is usually not greater than 4½ to 1, and often less than this.

Heavy lorries are, however, usually geared about 8 to 1, and it has not been usually considered that such a reduction is feasible in a single bevel. There is, however, one heavy lorry shown with a bevel having this gear ratio, and there seems no reason why it should not be successful. Further, it is quite possible that gear ratios in the heavy lorries and char-a-bancs may, in the future, be lower. The demand of users of lorries, like everything else, is for higher speed, and it has been proved that if an engine is to be light and durable it must not run very fast. Hence to get the extra speed the best thing will undoubtedly be to have a smaller gear ratio. In this case the bevel may easily prove superior to the worm. The worm has, however, proved very satisfactory, and has certainly stood up very well.

Double reduction axles are in a small minority, and this type seems unlikely to come into general use. It is more expensive than the worm or direct bevel and also heavier. So far as Army conditions went, the double reduction axle showed no advantage either in durability or efficiency over the worm, but it must be remembered that practically all the work of the Mechanical Transport overseas was generally in relatively flat country. It is possible that the worm will not show to advantage in a very hilly country, but even if the worm is not thoroughly satisfactory in this case, there are other drives which may be better than the double reduction in the axle. The internal gear drive to the back wheels is shown, curiously enough, principally on a large number of the lighter class of van carrying 1 to 2 tons, and made in the U.S.A. In Europe it was one of the early forms of drive, but did not come into general use though there have always been a certain number of lorries made on this plan. It was never used, however, except on the heaviest class of work.

There are some very distinct advantages in this drive over the ordinary double reduction. One of these is that the axle can be a straight bar or tube, and is, therefore, theoretically stronger for a given weight than the casing of the differential. A considerably greater reduction is usual with the internal gear than the final drive of the double reduction, and therefore the bevel crown wheel can be smaller, as also the differential gear and the casing.

The difficulty has so far been that it is not practicable to make the casing of the internal gear really oil-tight. While it appears to have distinct advantages over the double reduction in the axle casing, it seems that either the direct bevel or worm will be generally found more suitable, especially for moderate weights.

A detail point of great importance in the live axle is the substitution of forgings for castings in the axle casing. Up to date a very large proportion of the differential casings have been steel castings, and although these have on the whole been very satisfactory, there have been cases of their cracking. The great disadvantage of the casting, however, is the weight. Banjo frame forgings are used by some makers, but it is difficult to make these really light without great expense, and there are in any case two joints in place of one.

There are two practical alternatives to the casting. The one is to make the axle casing of pressed sheet steel in two halves welded together along the centre line, as has been done in light cars for a long time. This should make a very satisfactory axle a great deal lighter and probably more reliable than the cast axle. A very considerable number of axles made in this manner are shown. An alternative arrangement is shown by one firm in which the whole of the axle, including the differential casing, is stamped in one piece. This avoids the weld and should make an excellent job.

In the matter of back axle suspension there is a very marked tendency to do away with radius and torque rods and take both the drive and torque on the back springs. This considerably simplifies the arrangement and reduces the number of wearing parts requiring lubrication.

A good deal more attention is being paid to the lubrication of these parts. Where grease is used the cups are generally larger and more substantial than formerly, and will therefore not require filling at such frequent intervals. A great many makers are, however, now fitting oil cups in place of grease cups to the small parts such as spring shackle pins, &c., and these usually have spring caps which are convenient for oiling.

Engine and gear-box suspension generally does not show any great change, though there is a distinct tendency to improvement. In many cases the frame arrangement appears to be quite unnecessarily complicated and expensive, while often not appearing to produce a very good result when done. Thus it appears that if a sub-frame is used for either the engine or gear-box it should be used for both. The expense and weight of carrying the sub-frame a little further along would appear to be a good deal less than that of providing extra cross pieces for the other unit, while the alignment should be better. In many cases also either the engine or the gear-box or both are still carried on four-point suspension. While this will certainly work satisfactorily if carried well out and if the road conditions are not too severe it appears to have no advantages whatever over a good three-point suspension, while the latter has several distinct advantages, and need be no more expensive.

There are many theoretical advantages in following the practice usual in light cars and making the engine and gear-box one unit so that the two are rigidly lined up to each other and the whole put on a three-point suspension. The objection to this has usually been that it makes too large a unit, but it is questionable whether this outweighs the advantages, and it is interesting to note that there are examples of this system shown on more than one heavy chassis. In any case, if it is held that the combined unit is too large, the advantage of this construction can be largely retained, and separate units used by putting these on a sub-frame which is itself on a three-point suspension. Gear-boxes show little change, four speeds being usual in the heavy vehicles and three speeds in the lighter. The sliding gear with gate change has become almost universal, and with modern steels for the gear wheels and good heat treatment, gears give so little trouble that it is doubtful whether any other system is worth the extra expense. In the matter of clutches the cone clutch still is very largely used, though there is a tendency towards either single or multiple plate clutches. This appears an improvement, for the cone clutch, though it has done its work very well on the whole, has some distinct disadvantages. The most important of these is probably the fact that it has considerable inertia and therefore the wear and tear on the teeth of the gear is usually greater than with the disc type. The latter also, generally speaking, takes up more smoothly and is more uniform in action.

Engines generally show little change, though the detachable head is becoming more common. In fact, in engines more than chassis, makers ap-

pear to be sticking practically to their pre-war practice.

This is, doubtless, in many cases sound, for engines on the whole were very satisfactory. Valve arrangements show little change, the L headed cylinder being usual. Whether this is satisfactory appears to be rather doubtful. As fuel costs have increased so much it appears time that careful experiments were made to see what valve arrangement gives the greatest economy. Theoretically this should, of course, be the valve in head as it gives the least surface in the combustion chamber, but further information is wanted here. The valve in head has the advantage that smaller valves are required for a given power, and therefore the engine can often be made more compact and lighter. Lubrication has altered little, complete forced feed and troughs being both largely represented.

For ignition the magneto is almost universal but easy starting has been studied by several makers who fit "impulse" starters. This is in itself a considerable improvement, for large lorry engines are often a little difficult to start, and anything which makes this easier reduces the labour. Further, the easier an engine is to start the more likely the driver is to stop it when the vehicle is standing for a short time, and this saves fuel. Electric lighting is provided for on many chassis, but so far the electric self-starter is little used.

In most of the English chassis at all events the dynamo for lighting is belt driven. This appears to be rather a doubtful policy, as belts certainly take more attention than gears, and it appears to be time that any new engine design had provision for a gear driven dynamo and for a self-starter should the latter be required. It is quite possible that in the near future the latter will come into use even in the purely commercial heavy vehicles, as in this case there is no doubt that the engine will be stopped more often when the vehicle is at rest and petrol saved.

An interesting development is the large pneumatic tyre for the heavy vehicle. The majority of makers show at least one vehicle fitted with these. The diameter for a 3-ton lorry or full-sized char-a-banc is about 10 in. Many makers in place of using such a huge section use twin tyres on the back wheels which are of somewhat smaller size.

The whole question of tyres is probably a matter of speed. There are, undoubtedly, many serious problems in using pneumatic tyres on such heavy vehicles. One is the question of how far the steering will be affected if the tyre bursts at speed. With very large tyres the wheel will drop something like 10 in. Experience is the only thing which can show whether this is a serious matter or not.

Another point is the question of time lost in case of a puncture. This may often be a serious matter when vehicles are run to a time table. A man going to catch an important train in a private car usually allows himself time to change a wheel in case of a puncture, but this only takes a short time. Jacking up a heavy vehicle and changing a tyre will however be a more lengthy process. There is also the question of cost. Theoretically there does not appear any reason why a tyre filled with air should cost so very much more than one of solid rubber, but at present prices it certainly does. The great advantage of the pneumatic is, of course, the saving in vibration in the vehicle, which reduces the cost of small repairs. Further, in the passenger vehicles there is the increased comfort of the passengers, which will probably bring in increased receipts.

Balancing up these advantages and disadvantages, the whole matter will probably resolve itself into a matter of road speed. Up to certain speeds the solid tyre is quite satisfactory and the saving in vibration by the pneumatic will not be worth its disadvantages. Above a certain speed, on the other hand, the pneumatic will probably be a practical necessity as it has proved on the lighter vehicle. The position is the same as that of the heavy steam lorry and traction engine, where the steel tyre answers perfectly for really low speeds but above them the rubber is a necessity. The whole question of heavy vehicle speeds is a matter for very serious consideration. Probably as a matter of economy it would be best if heavy goods were only taken along the road at moderate speeds, as the saving in wear and tear of both vehicle and road would be considerable. This matter is, however, in the hands of the user and at present he demands high speeds. Many makers have for years fitted their vehicles with governors limiting the speed to what they consider the maximum economical, but it is notorious that a very large proportion of the users remove the governors as soon as they get the vehicle, and run it at far higher speeds.

The legal aspect of the case here will also have a considerable effect. The speed limits imposed by law are in many cases so ridiculous that they are largely a dead letter, and few drivers of light cars ever go out without very considerably exceeding the speed limit. So with the heavy vehicle which is often driven at two or three times its legal limit. It is quite clear that it is impracticable to enforce the law as it now stands, and if any real control is to be kept over the speed of road vehicles the legal limit should be a reasonable one which should be generally enforced. To have a nominal limit of 12 miles an hour on types of vehicles which are habitually driven at over 20 in the London streets and often over 30 on country roads is, however, absurd. The tendency appears in everything nowadays to be for increased speed, however, and it seems probable that this will eventually bring the pneumatic into general use for at all events a considerable part of the heavy vehicles.

Bearings generally show little change. The engines as a rule have plain bearings all over, though some makers who have used ball bearings for the crankshaft main bearing still retain them. One maker who previously used plain engine bearings now has a ball-bearing shaft with only two main bearings.

Generally speaking, the ball bearing has not shown any special advantage for engine work over the plain bearing, both doing their work excellently if well designed. The main advantage of the ball bearing is probably that it considerably shortens the engine. Another very distinct advantage may be found in it, however, when the engine and gear-box are built up as one unit, and that is that the crankshaft cannot be adjusted out of line with the gear-box, as may be the case if ordinary plain bearings are let together. For gear-boxes the ball or roller bearing is almost universal.

Wheel bearings are still very various. Plain bushes, floating bushes, bushes fixed to the pin, ball and roller bearings are all used by experienced makers, and all appear to do their work well if of good detail design. Here the great advantage of the ball or roller bearing appears to be that it requires no lubrication, and it is mainly a question whether this advantage is worth the extra weight and cost. Springs have certainly improved, especially in some of the chassis of new design, and there is now a tendency to make them wider and longer.

Brakes are now generally satisfactory. There is still a diversity of opinion as to their position, some makers putting both brakes on the back hubs, some putting the foot brake at one or other end of the propeller shaft. The latter generally has the advantage of giving a greater braking effort for a given foot pressure and also has the advantage that heating of one brake does not affect the other. Having the brakes both on the back hubs, however, reduces the wear on the driving gear and differential. Several makers who use worm drive put the foot-brake on the worm spindle behind the axle. This appears a good position as it avoids taking the braking strain through the universal joints and also puts the brake where it is well cooled.

One of the most interesting developments in the Show is that of tipping bodies. Rapid unloading is of great importance nowadays and a very large proportion of the make [lorry makers show some form of tipping body with a power tipper. These devices are essentially of two types, the hydraulic and the mechanical. In the former the tipping is effected by a ram supplied with oil under pressure from a pump driven by the power of the engine, usually by a shaft driven from the gear-box. In the latter the body is tipped by mechanical gear driven usually from the gear-box. While the hydraulic gear seems to predominate the mechanical seems to have advantages in being, on the whole, simpler and easier to understand, and it is also quite positive both in raising and lowering. Which will eventually prove the best can only be ascertained by considerable experience.

In detail, it is interesting to note that a very considerable number of the gears lift the body at a point very near the hinge on which it tips, while others lift it from the front end. Unless there is some definite reason for lifting it from far back, it would appear to be the best practice to lift it from the front end. The majority of the bodies tip at the back only. At least one, however, tips either from the back or either side. To what extent this is necessary must be decided by the user, but there is no doubt that it will be useful in many cases, and it is a matter which should receive consideration.

In addition to the heavier type of lorry there are a large number of vehicles intended for parcels vans to carry from 10 cwt. to a ton or a little more. A good many of them come from America. Among these there is not a great deal to note. They are usually fitted with pneumatic tyres and follow in most points the construction of the ordinary pleasure car with slight variation, in fact, in some cases, the chassis are the same as is used for the pleasure car, with such minor differences as less rake to the steering, &c. Pleasure car design progressed in the U.S.A. very rapidly during the war and has become more or less stereotyped in its main features, and there is therefore a great deal less of note in the light vehicle than the heavier one.

The point of greatest interest is the back axle drive. Many of even the quite light vans have internal gear-drive to the back wheels. The necessity for this is not apparent. In the heavier vehicles the speed is slow, the wheels large, and such a gear is used as a convenient means of getting large gear ratio so as to allow of the engine running its full revolutions at the ordinary speed of the vehicle. In the lighter vehicles the speed is higher and the wheels are smaller, while it is not desirable to run the engine very fast in order to keep down upkeep. There appears therefore to be no reason why a direct bevel should not be used for all ordinary work, and even if higher ratios are required than can be got conveniently with the bevel the worm should be thoroughly satisfactory under the light loads and cheaper to make and maintain. The majority of the lighter vans have the engine and gear both built in one unit with the change speed lever on the gear-box following car practice, and, in fact, this unit is often the same as used in the cars.

Taking a general review of the Show, there is no doubt of the great improvement which has taken place in the commercial vehicle in the last few years. The machines shown are practically all either well-tried patterns which have proved satisfactory, or else new designs which have been well thought out in view of past experience. The line of progress in the future will probably be in the direction of considerably simplifying upkeep, of reducing the cost of manufacture, and of making the vehicle more convenient to drive. There is still undoubtedly a margin for progress in these points.

The matter of upkeep is almost entirely a matter of detail which we have recently dealt with at considerable length. Progress here will consist in carefully considering the cost of upkeep in every point, not only in the matter of actual cost of repairs but also in the time spent in oiling, greasing, filling-up, cleaning, &c. Cost of production will have also to be very carefully considered, for it is just as extravagant to waste money in first cost as in upkeep. It is an unfortunate fact that there is a tendency in all engineering discussions to ignore the question of first cost as "unscientific." Fuel economy is considered for instance, a much more scientific matter than first cost. Yet fuel economy is usually only of importance from the pecuniary standpoint, and from this point of view, first cost is equally important.

In view, however, of probable competition from other countries, this matter of first cost is one which will have eventually to be very carefully considered in the designs. Many of the chassis give one the impression that though they are excellent productions and will do their work very well, the design could be a good deal cheapened without in any way

interfering with their efficiency. In fact, in many cases a reduction in first-cost also means a reduction in the cost of spare parts. One heavy lorry has a frame consisting of two straight longitudinals and three crosspieces. Others have many crosspieces and often an inside frame as well. The latter will be far the more expensive and unless the customer gets proportionate advantage there is waste of money. The same may be said of the back axle suspension, universal joints and many other parts. For instance, the fewer the joints in the back axle suspension, the less the cost of these. So far from this being a disadvantage to the user, it is generally an advantage, as it means fewer joints to lubricate and replace when worn.

This matter, cost in design, requires to be very carefully considered now, in both the general layout and all the details. In the early days of any new type of machine there are too many difficulties in making it perform its work at all satisfactorily to trouble too much about cost, but we have got well beyond this stage in the commercial vehicle now and cost should be very carefully considered. Convenience of driving should also receive more consideration in many cases. The pressure required to move the clutches of some machines is excessive, and other details entail unnecessary exertion. The more the convenience and comfort of the driver is considered, the more he is likely to look after his vehicle. In the Army, for instance, some makes of vehicle became very unpopular with the drivers and got a bad name generally, simply because the physical exertion required to drive them was excessive. The result was that drivers did not take the same interest in them that drivers of more popular makes did. The driver felt that, after all, if his machine broke down he couldn't get anything much worse, and might probably get something better.

THE LATE MR. C. J. BOWEN COOKE, C.B.E.

The news of the death at Falmouth, on Monday last, the 18th inst., of Mr. C. J. Bowen Cooke, C.B.E., chief mechanical engineer of the London and North-Western Railway, will probably come as a surprise to many who were not aware that he had been ill for several weeks. Mr. Cooke was born in 1859, so that he was only 61 years of age. He was the son of the rector of Orton Longueville, near Peterborough. His early education was carried out privately and at Cheltenham College, after which he spent a year at King's College, London, subsequently going to the Technical High School, Neuwied, Germany, for one year.

In 1875 he commenced his pupilage of five years under Mr. F. W. Webb, on the London and North-Western Railway, in the locomotive department, and his connection with that company remained unsevered up till the time of his death. At Crewe he went through the various shops and departments and offices, as well as the running sheds, and at the termination of the period he was appointed, in 1880, assistant superintendent in the locomotive running department for the Southern Division of that railway. This position he held under Mr. Mumford, with headquarters at Rugby. From 1899 till 1903 he was running superintendent of the Southern Division, with offices at Crewe, and in 1909 he succeeded Mr. G. Whale as chief mechanical engineer. Mr. Cooke's career has thus been intimately connected with the London and North-Western Railway during one of the most interesting phases of British locomotive history. For the whole of the earlier part of his experience he was in close touch in the Southern Division of the running department with the performance of the now obsolete Webb compounds. Mr. Whale commenced the conversion of these engines and Mr. Bowen Cooke, when he assumed charge of the department, continued the work.

Mr. Bowen Cooke has been responsible for a good many new classes of engines on the London and North-Western. Probably the most famous is the "Sir Gilbert Claughton" class, brought out in 1913. It is hardly necessary to record that this was a four-cylinder superheater locomotive of the 4-6-0 type. The cylinders were 16 in. in diameter by 26 in. stroke, and the driving wheels were 6 ft. 9 in. in diameter. The total heating surface of 2,232 sq. ft. included 486 sq. ft. of superheater surface and the grate area was 30.5 sq. ft. The weight of the engine and tender was 116 tons. Only two sets of Walschaert valve gear operated the four cylinders. The "Sir Gilbert Claughton" soon had some excellent performances to its credit, and with a load of 360 tons behind the tender on one occasion developed 1,358 i.h.p. and 975 draw-bar horse-power. Before this class was brought out Mr. Cooke had introduced a 4-6-2 type of superheater tank engine, a class of 0-8-2 type shunting engine, and a class of 0-8-0 superheater goods engine. In 1911 we believe that out of 74 engines constructed at Crewe 61 were superheater engines. In that year the five thousandth locomotive to be built at the Crewe works was turned out.

In 1910 Mr. Bowen Cooke and Mr. J. G. Churchward of the Great Western Railway arranged for a very interesting interchange of locomotives with the idea of trying the latest types of each

Photo Elliott & Fry.

MAJOR C. J. BOWEN COOKE, C.B.E.

Company under the running conditions of the other line. The engine provided by the London and North-Western Railway was a 4-6-0 locomotive of the "Experiment" class, named the "Worcestershire." We are afraid that this test must go down to history as proving that the London and North-Western engine of that date was unequal to meeting the demands of the Great Western Railway main line service.

In 1912 their Majesties the King and Queen visited the works at Crewe, and Mr. Bowen Cooke had the honour of conducting the Royal Party round the shops. During the war the locomotive works at Crewe did a vast amount of valuable work of the most varied kinds for the forces overseas. Mr. Cooke himself was a member of the War Manufacturers' Sub-Committee of the Railway Executive Committee, in which capacity he performed valuable services to the country. He was also a member of the Locomotive Superintendents' Sub-Committee of the Executive Committee and of the Machinery and Metals Committee of the Inventions Panel appointed by the Ministry of Munitions. At Crewe a type of tractor was developed out of a Ford car, armoured trains were built, a great deal of forged and other work turned out in addition to small material, overhead cranes, rails, and so on. For his war services Mr. Cooke was made a Commander of the Order of the British Empire in 1918.

Mr. Bowen Cooke was made a member of the Institution of Civil Engineers in 1905. In 1912 he read a paper before that body on "The Mechanical Handling of Coal for Locomotives." He was elected a member of the Institution of Mechanical Engineers in 1912. He was a J.P. and C.C. for Cheshire, and held the rank of major in the Engineers and Railway Staff Corps. He was very keen on fire brigade work, and had charge of the English steamer work at the International Fire Congresses at Antwerp and Brussels. Mr. Bowen Cooke was the author of a popular book entitled "British Locomotives," first published in 1903. This very quickly ran into three editions. It did not pretend to be a text-book, but was a record of the classes of locomotives in use on British railways. Mr. Bowen Cooke followed this with another book, entitled "Modern Locomotive Development," which contained substantially the material which formed two lectures given by him at the request of the War Office before the Royal Engineers' Institute at Chatham. Mr. Bowen Cooke's death, while still actively engaged in his profession, will be deeply regretted by a wide circle of friends and particularly by those who had the good fortune to work with him as a colleague on the various important committees of which he was a member.

NOTES.

Standardisation in the Motor Vehicle Trade.

The work of the British Engineering Standards Association has never, we think, met with serious criticism. The work it has carried out is so necessary and the results have proved so valuable that engineers and manufacturers would be very sorry to be deprived of its aid. The earlier work of the Association was necessarily of a basic character, covering to a considerable extent details of what are the raw materials of many trades. Much of this preliminary work has now been completed, however, and the Association is able to devote more attention to the details of special trades. A great deal of work of this kind is at hand waiting to be done, and it is to be hoped that manufacturers will do all in their power to assist the Association in continuing and extending their operations. In many cases trade associations could introduce standardisation of their own without waiting for help from the Standards Association, but there would, at times, be danger in this practice. On the other hand, in many directions the necessities of the situation are so glaring that one is impatient of further loss of time. The motor trade furnishes an excellent example. The matter was referred to by Dr. T. Blackwood Murray in his presidential address to the Institution of Engineers and Shipbuilders in Scotland delivered last Tuesday. Dr. Murray pointed out that in 1914 there were 60 different sizes of solid rubber band tyres for commercial vehicles in commerce. The British Engineering Standards Association has been able to recommend the reduction of this number to ten. This is a fair example of the kind of thing which is hampering the development of the motor trade in this country. As Dr. Murray said, enormously more has been done in America than in this country in standardising motor-car details, and as is well known it is possible in that country to buy a standard engine which will replace another of a different make. Until main standard dimensions for certain car parts are determined, it will be impossible for the assembled car ever to develop in this country. Some trade groups, of course, are having a chassis built in one works, the transmission in another, and so on, but the car so produced is not an assembled car in the American sense. It is merely another British car differing possibly in almost every dimension from all others, but distinguished by the fact that most of its parts have been made by sub-contractors. Standardisation of this kind is a trade matter rather than one for the British Engineering Standards Association. We do not know if this country will ever attain to it. It is possibly of too radical a character to be accepted by our motor firms, and would, in any case, take several years building-up before it became of much service. Whether, however, we are to have the assembled car, or not, great good may be done in similar directions to that of the solid tyres referred to above. As an example, it is interesting

and somewhat painful to know that on 61 motor vehicles examined in France during the war there were 65 different sections of steel employed for the springs. This total lay within a range of from 1½ in. to 4 in. wide. A little standardisation might profitably be considered here.

The Development of Non-Ferrous Metallurgical Research.

Mr. Ernest A. Smith, A.R.S.M., delivered, on the 15th inst., as Chairman of the Sheffield Section of the Institute of Metals, an address having the above title, in which he traced the progress made in the scientific study of metallurgical problems, and in that of the constitution of metals and alloys. He recalled that the establishment of the Alloys Research Committee by the Institution of Mechanical Engineers in 1890 formed the commencement of systematic investigation in relation to the structure and mechanical properties of metals and alloys. According to the speaker one of the most encouraging signs in connection with modern metallurgical research had been the increasing sympathetic co-operation between the workers in the realms of ferrous and non-ferrous metallurgy, and also between metallurgists and engineers. Whilst it was true that the results of the more progressive research in connection with the constitution and properties of iron and steel had been of considerable assistance to non-ferrous metal research, it was equally true that progress in ferrous research had been greatly stimulated by investigations on non-ferrous metals, these latter, in many cases being far more suitable than the ferrous for studying the constitution of metals and alloys generally. Further, the scientific developments of industry during the past few years had been the means of bringing metallurgists and engineers in touch with each other to an extent which would have appeared almost impossible in pre-war time, and there was encouraging evidence that this co-operation had been appreciated on both sides. Non-ferrous metallurgy—the branch with which the speaker dealt more especially in his address—involved a number of problems of fundamental importance, and affecting the whole of the industry; the solution of these problems could only be arrived at by many workers acting conjointly in investigating special branches of the subject. This had been fully realised by a number of progressive manufacturers interested in non-ferrous metals; it led them to take active steps to establish a Research Association on the lines suggested by the Government Department of Scientific and Industrial Research. The British Non-Ferrous Metals Research Association was formally incorporated in January last, and every effort was being made, said the speaker, to bring its object and aims before all persons and firms connected with the industry. Birmingham, being an important centre of non-ferrous metal manufacture, was selected as the home of the new Association, but the scope of the Association's activities were national and embraced all the various branches of the non-ferrous metal industry throughout the country. The speaker then briefly indicated the directions in which the Association's activities were being applied, the work bearing, among many other points, on the production of sound brass and copper castings, the atmospheric corrosion of non-ferrous metals, the study of the properties of metals and alloys as influenced by thermal and mechanical treatment, the exact cause of, and the remedy for, piping in rods made by the new extrusion process. In concluding his address, he recalled the interesting figures on the development in the use of non-ferrous metals in engineering and shipbuilding, which Sir James McKechnie quoted in a short speech he delivered at Barrow-in-Furness, on the occasion of the meeting of the Institute of Metals recently held in that city, and which we recorded in a former issue.

Recent Machine Tool Developments: Erratum.—In our article last week on "Recent Machine Tool Developments" (page 494 *ante*) an error appears in the titles under some of the figures. In some cases the machine illustrated on pages 495, 496 and 497 has been designated a plano-milling machine, instead of "plain milling machine." This was corrected after a few copies had been printed, and in most cases therefore no heed need be paid to this paragraph.

LITERATURE.

Water Powers of British Columbia. By Arthur V. White, Consulting Engineer. Commission of Conservation, Canada, assisted by Charles J. Vick. Ottawa: Commission of Conservation, Canada.

With the ever-increasing price of coal, and the inevitable ultimate exhaustion of known supplies, the possibilities of the water-power resources of the world are gaining in significance. Water-power, properly conserved, provides a practically inexhaustible source of energy, and this fact, coupled with the enormous inroads which are at present being made on the finite supplies of combustible materials which are available, lends something more than a local interest to Mr. White's book on the subject of the water-power resources of British Columbia. This interest is further accentuated when the close relationship between Canada's industrial future and her very considerable possibilities in the way of hydro-electric developments is taken into consideration.

In this matter of water-power the Dominion in general, and British Columbia in particular, is fortunately placed. The problem of utilising to the best possible advantage the available sources of such power in the province in question is, however, one which presents some unusual features, and for this reason is more than usually interesting. Mr. White tackles this problem in a most comprehensive manner, and with due regard to those purposes, other than turbine propulsion, to which the available water supply must be put. The interests of the salmon-fishing industry—one of the most important industries of the province—of irrigation for agricultural purposes, of urban and rural water supply, of navigation and logging operations, and even of the artistic susceptibilities of the beauty-loving tourists, are alike sympathetically considered. It is pointed out that certain of these interests take precedence over power development in importance, and that no power development scheme should be permitted which would have a malign influence on such interests. But it also transpires in subsequent pages that there is ample water available for all purposes, with a very material balance left over for power development, and that the construction of works for this purpose could be made to assist the processes of log-driving, navigation and irrigation rather than operate to their disadvantage.

As regards the general principles involved in hydro-dynamics and hydrometrics Mr. White has nothing of striking originality to say, although he deals at some length with these matters. Indeed, in the whole treatment of his subject the author is largely non-technical and entirely non-mathematical. It is a book that any business man could read with as much facility as can the engineer. And yet it is a book rich in data of an exceedingly comprehensive nature. Such data, however, relate to conditions in British Columbia, and to a less extent, to those in the United States, and are of interest chiefly to those who contemplate the utilisation of the water-power available in Canada's most westerly province. To these, rather than to the general reader, the author makes his appeal, and when it is considered that the estimated available horse-power of the rivers of British Columbia is 3,000,000, of which only some 250,000 has so far been utilised, it will be realised that the possibilities of cheap power afforded by the inland waterways of this province are such as to attract the attention of capitalists the world over. Developed to their fullest extent, the falls and rapids of the province are capable of a power development equivalent to that of some 18,000,000 tons of coal per annum, on the basis of average steam-plant practice operating 24 hours per day for 300 days in the year. The value of such power is obvious, and is enhanced when it is stated that the power estimate in question excludes certain streams in which power development is impracticable on account of the damage which would result thereby to the salmon-fishing industry.

The water legislation of British Columbia is set forth in considerable detail, together with the steps which are necessary under the Water Act in order to obtain the requisite authority to carry out power development projects. These chapters are of interest only to those locally concerned, and to those who actually contemplate such undertakings. The chapters dealing with the topography of the province, and with such questions as precipitation, run-off, maximum and minimum flow as observed on the several streams and rivers dealt with, have a more general interest. The data in connection with these factors are of a very comprehensive character, and are excellently presented both in their tabular and diagrammatic forms. The problem of storage, both natural in the way of lakes, snow-fields and glaciers, and supplementary artificial storage by the raising of lake levels, is dealt with very fully. This is a question of vital importance in view of local conditions. The principal waterways of the province have their source in or near the Rocky Mountains, and flow thence to the coast. As a result of this, and of the extremely cold winter experienced in the Highlands of the interior, the average run-off during the winter months is very much less than that of the spring and early summer, when the thaw releases the water stored in glaciers and snow-fields. The ratio of maximum to minimum stream-flow is, in some cases, as high as 30 : 1, and averages about 20 : 1. It is therefore obvious that, in order to obtain anything approaching the best results from the water-power available, some method of supplementing the natural storage capacity of the various lakes, and of partially controlling their out-flow, is necessary so that a greater uniformity of flow through the turbines of power stations may be obtained. The whole of this question is very thoroughly dealt with in the text, and the possibilities of the use of auxiliary steam, gas or oil power during periods of minimum flow are also discussed.

Particulars of existing power developments are given fairly fully as regards essentials, but here again the engineer will find little of a technical nature to hold his attention. The problems of construction which would naturally be met with in works of this nature are hardly touched on, nor are any structural details given. Indeed, the aim of the whole volume is to give broad facts and detailed data rather than to treat of the purely engineering problems involved in the actual carrying out of power development schemes. The author's own phrase in his foreword, "This report is a compendium of data relating to the water-power resources of British Columbia," pretty well indicates the scope of the work and the object with which it was published. This object is amply fulfilled, the manner in which the data are presented, and their exhaustive nature, being the two most important and striking features of the volume.

BOOKS RECEIVED.

Modern Explosives. By S. I. Levy, B.A., B.Sc., F.I.C. London: Sir Isaac Pitman and Sons, Limited. [Price 3s. net.]

City and Guilds of London Institute. Department of Technology. Programme for the Session 1920–21, containing General Regulations for the Registration of Classes and the Examination of Candidates, together with the Syllabuses. London: John Murray. [Price 2s. 6d. net.]

American Civil Engineers' Handbook. By Mansfield Merriman, Editor-in-Chief. Fourth edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 33s. net.]

Topographic Maps and Sketch Mapping. By J. K. Finch, C.E., A.M. First edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 13s. 6d. net.]

Drainage Engineering. By Daniel William Murphy, A.B., A.M., Ph.D. First edition. New York and London: McGraw Hill Publishing Company, Inc. [Price 15s. net.]

Kelly's Directory of the Engineers, Iron, Metal and Electrical Trades, 1920. London: Kelly's Directories, Limited. [Price 45s.]

The Efficiency of Pumps and Ejectors. By E. C. Bowden, Smith, M.I.Mech.E. London: Constable and Co., Limited. [Price 14s. 6d. net.]

State of Tennessee. State Geological Survey. Bulletins 23 *Administrative Report of the State Geologist, 1919, including Recent Studies of the Upper Cretaceous of Tennessee.* By Bruce Wade, *and Barite Deposits in Upper East Tennessee,* by C. H. Gordon. No. 24. *Oil and Gas resources of the North-eastern Part of Sumner County, Tennessee.* By Kirtley F. Mather. Nashville: Williams Printing Company.

The Output Problem. By J. E. Powell. London: The Library Press, Limited. [Price 6s. net.]

ADJUSTABLE THREAD SNAP GAUGE.

CONSTRUCTED BY THE COVENTRY GAUGE AND TOOL COMPANY, LIMITED, ENGINEERS, COVENTRY.

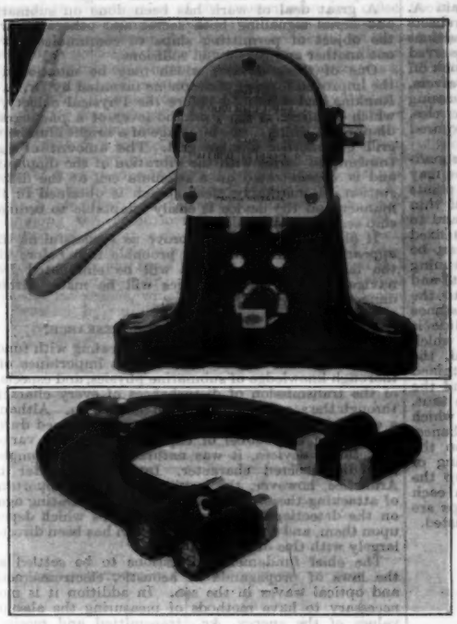

FIG. 1.

FIG. 2.

AN interesting development of the adjustable plain snap gauge is a new adjustable thread snap gauge, brought out by the Coventry Gauge and Tool Company, Limited, for whom Messrs. Alfred Herbert, Coventry, act as agents. This gauge is illustrated in Figs. 1 to 4 herewith, Fig. 2 showing one of the adjustable plain gauges with "go" and "no go" anvils, from which the thread gauge originated. In place of the plain anvils the thread gauge has two sets of threaded anvils. The outer pair are full-form gauges of pitches which can be changed according to the work to be checked. The diameter being adjustable these anvils have only to be correct to form and pitch. They are cut with a precision hob, lapped, and are tested optically for form and also tested for pitch. This pair acts as the "go" gauge. It can be set to slip gauges set for the core diameter, or to a plain core plug gauge, or to the tap which is producing the hole in which the screws to be tested, will be used.

The inner pair of anvils are the "no-go" gauge. These anvils are cleared on the major and core portions of the thread, and test only the effective diameter, thus providing a test for that part of the thread on which its strength is dependent. This test is, of course, not possible with the usual ring gauge which does not reveal the fact that a screw which it passes may be weak in the flanks. These anvils may be set to a predetermined amount below the standard size, for the permissible limit of thinning, when threads passing between them on inspection would be rejected. The anvils have the amount by which they are topped off, engraved on them, so that they may be set to slip gauges or plug gauges in the ordinary way. This second set of anvils is an effective check on the first.

Fig. 3 shows one of the gauges, and also an anvil and the adjusting key. The drawing, Fig. 4, of one head, shows how the adjustment is obtained. The heads of the frame are bored and lapped to ensure perfect alignment. The anvils are tee-shaped, the shank being round and carefully fitted into the boss of the frame. They have flat sides, and these fit projecting shoulders on the frame, keeping the thread in correct position. The outer portion of the hole in the boss is screwed to take a threaded ferrule which provides the necessary adjustment over a range of $\frac{1}{4}$ in. Between this and the end of the shank of the anvil is a hardened steel ball pierced by a hole through which passes a locking screw, passing also freely through the ferrule, but screwing into the anvil shank. It will be seen that by screwing the ferrule in or out the anvil may be adjusted, while when the right position is obtained by tightening up the locking screw the pressure exerted on the ball enables a final infinitesimal adjustment to be made. With this arrangement the anvils may easily be set to an accuracy of 0·0001 in., and, as already pointed out the gauge tests for form, its value is far ahead of any commercially produced hardened ring gauge.

These gauges are made in sets of frames varying by $\frac{1}{4}$ in., with the anvils interchangeable so that a range of pitches can be used, and any screw of any diameter can be tested within the frame sizes a user may have. As the gauges are set from plain cylindrical gauges it is not necessary to have special ring gauges for reference as standards. With a periodic inspection the error from wear can be kept within very small limits. It may be mentioned that the threads of the gauge are relieved, and the faces may be reground right back to the full width of the tee-head, and they may still be used for the same diameter if necessary in another frame. After adjustment the gauge is sealed with a press which may be kept locked by the inspector. The press embosses a monogram on the lead seals which cover the locking and adjusting screws. It is, therefore, impossible to get at either of the latter without defacing the seal. The press supports the frame on a block between the anvils so that no pressure is excited on the latter in the operation of sealing. The press used is shown in Fig. 1.

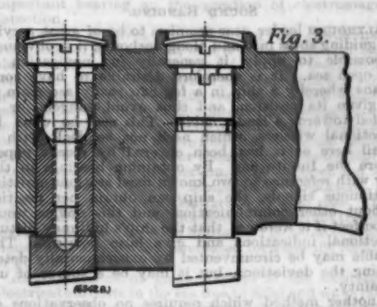

Fig. 3.

NOTES ON NEW BOOKS.

AN engineering pocket book compiled on quite new lines is "*The Engineering Inquiry*," by Mr. Tomey Thompson. It states the nature of the information which is to be specified in inquiries. For example, under "Press, Forging," the following is given: "Specify in inquiry (1) Maximum weight and overall dimensions of largest ingot to be handled. (2) Full specification of material to be forged; ordinary carbon, mild, or high tensile alloy steel, &c. (3) General description of work to be done by press. (4) Pressures available: hydraulic, steam." A guide to further information is given for cases where the press would be required for abroad and for those covering erection. We have taken this example at random out of a series covering close upon 280 pages of the book. The machines, apparatus and material for which the kind of information desired is indicated are arranged alphabetically. The book appeals to a wide circle comprising contractors and merchants, by whom it will be found most serviceable. It is published at the price of 7*s.* 6*d.* by Messrs. Simpkin, Marshall, Hamilton, Kent and Co., Limited, Stationers' Hall Court.

All who are interested in the late Sir Hiram Maxim will be glad to know that a book entitled "*The Life and Work of Sir Hiram Maxim*," by P. Fleury Mottelay, is published by John Lane, The Bodley Head, Vigo-street, W. 1, at the price of 7*s.* 6*d.* net. The subject of this biography was such a prolific inventor in almost every branch of science and industry that it is not surprising to find that the book deals practically exclusively with his work and his inventions. Illustrated descriptions are given of his principal schemes, such as his gun, projectiles, fuses, his improvements in explosives, and others. The list of his American and British patents covers about 12 closely-printed pages. His first patent was taken out in August, 1866, when he was 26 years of age, and his last in August, 1916, a period of exactly fifty years. The book may be considered as a summary of the life's energies of a great engineer. It contains an introduction by Lord Moulton.

If any additional evidence were needed as to the strength and importance of the Federation of British Industries it might well be obtained from the "*Export Register*," which has recently been published for the Federation by Industrial Publicity Service, Limited, 4 to 7, Red Lion-court, London, E.C. 4. The federation, it may be remarked, since its inception only four years ago, has enrolled upwards of 1,300 direct members, including some 200 trade associations, and is in touch, either directly or indirectly, with about 20,000 British manufacturers covering every industry in the country. Naturally, a list of the products of these firms, even when confined to the more general headings only, is fairly extensive, and the list ranging from abrasives to zirconium salts given in the "*Export Register*" occupies nearly 160 pages. This is probably the most valuable section of the book, and it will certainly be of considerable utility to British buyers as well as to overseas clients. Other useful features are, however, an alphabetical list of firms and companies who are direct members of the federation, giving the names of overseas agents in each case, and a list of trade associations arranged in groups according to the industry with which they are connected, and including a list of the exporting members of each association. The industrial grouping system, which was devised by the federation and adopted as the basis of its organisation, has already proved to be of the greatest service in bringing industrial problems to the notice of the people most concerned with the least possible delay. This advantage, we believe, has been fully appreciated by Government Departments and other outside bodies with whom the federation works in close accord. The work of the federation is, of course, mainly in connection with questions of policy, but it promotes the interests of its members, and incidentally those of the community at large, in many other ways, some of which are set out in the volume under notice. The publication of the "*Export Register*" itself, by providing overseas buyers and also British merchants and exporters with reliable information as to the source of the various products of industry, is another means by which the activities of the federation are likely to benefit others than its actual members. The price of the book is 25*s.* post free, and it can be obtained from the publishers, whose name and address are given above; it is printed in several foreign languages as well as in English.

THE UNITED STATES' FREIGHT SITUATION.—Some slight improvement appears to be noticeable in ocean shipping at the ports of the United States, says *Commercial America*. The number of vessels receiving clearance papers at New York shows an increase, and ships seem to be exposing less of their hulls than formerly. Other Atlantic seaboard ports are also doing better. Freight conditions on the Pacific are somewhat clouded by several influences; while at some shipping points there is an abundance of a certain kind of business, at other ports little or nothing is being done. There is no getting around the fact, however, that taking American ports as a whole it will require a great expansion of commerce to furnish employment for all the ocean tonnage offering.

MODERN MARINE PROBLEMS IN WAR AND PEACE.*

By C. V. Drysdale, O.B.E., D.Sc.

(*Concluded from page* 523.)

Sound Ranging.

Although leader gear promises to be of great service for guiding ships into and along harbours, it is obviously impossible to apply it generally for navigation in the open sea. It is therefore desirable to have some means whereby a ship in a fog can easily ascertain or be given its position, and thus avoid dangers, or be guided towards a leader cable. This may be done by directional wireless, which need not be dealt with in detail here as it has been covered by recent papers before the Institution. By obtaining bearings in this way with reference to two known fixed stations emitting continuous signals, the ship can obtain her position without other communication, and this device would be perfect if it were not that the ship's hull may disturb directional indications and give false bearings. This trouble may be circumvented by experimentally determining the deviations, but it may be a source of uncertainty.

Another method which requires no observations on board ship is by means of submarine sound ranging. If a sudden impulse such as an explosion is produced at a given point the disturbance spreads out in all directions and can be received on three or more fixed hydrophones or shock receivers. If there are only three receivers and the explosion takes place at the centre of a circle passing through them, the impulse should reach all the receivers simultaneously, but if it emanates from any other position it arrives at different times, and if these time differences can be accurately determined and the velocity of propagation is known, the position of the source can be calculated (Fig. 19). This device, the introduction of which to marine service has been chiefly due to Professor Bragg, and which has been developed by Captain Boulding, has been of considerable service in the war for locating submarine explosions, apart from its well-known application for locating guns in land warfare; but it can obviously be equally applicable for locating ships if they drop depth charges or employ other methods such as the Thornton spark for producing strong submarine impulses. It is, of course, necessary in this case for the ship to notify the sound-ranging station by wireless of its need for location, whereupon the station wirelesses back instructions to make the explosion and signals the location as soon as the result has been worked out.

Probably the most promising method of location would be by means of simultaneous wireless and sound impulses sent out at intervals from a fixed station. If the ship were provided with a wireless equipment and a hydrophone, either or both of them being directional, the direction of the source would be easily determinable, and its distance by the interval of time between the arrival of the two signals—nearly a mile for each second of the interval. This may very likely prove to be far the most convenient and accurate method of location, and arrangements are being made for developing it.†

In the meantime great improvements have been effected in the ordinary three-receiver sound-ranging method with the object of simplifying the observation and determination of the source. Up to the present the times of arrival have been obtained by means of hydrophones connected to separate strings of an Einthoven galvanometer, which involves a photographic record which has to be developed and measured before the position can be calculated. Dr. A. B. Wood and Mr. Ford have greatly improved this process by what they call their phonic chronometer, which enables the times to be read directly on dials to an accuracy of 1/1,000th of a second. The principle is analogous to that of the author's roller stroboscope, in which a wheel with stroboscopic slits rolls on a cone which is kept revolving at a constant speed by a phonic wheel motor actuated from a standard tuning-fork.

In the phonic chronometer a vertical cylinder is maintained in rotation in the same manner, and three small pivoted discs are arranged to be pressed in contact with it by differentially-wound electromagnets when the current through one winding is broken. When the second circuit is also broken, the disc springs back from contact with the roller but immediately touches against a brake which stops it instantly. These discs are provided with pointers registering the times of contact to 1/1,000th of a second, and with light gearing extending the total time to 10 secs. or more, so that the three time intervals can be directly read off on the three dials. Apart from its value for sound-ranging, this chronometer should have valuable applications for gunnery and general testing, as it is remarkably compact and reliable in comparison with any high-speed chronometer hitherto devised.

Instead of ordinary microphones the hydrophones employed with this device have single-point contacts, which are broken by the arrival of the impulse, but which can be restored by the operator through the agency of a magnetising coil. Extremely sensitive receivers of this type have been devised by Mr. Burnside, who employs a hollow silver-plated iron ball to make contact with a point on the diaphragm. This ball is arranged to have perfectly neutral buoyancy in a liquid inside the receiver case, so that it has no gravity control, and it is attracted into contact with the disc by a small coil.

By means of these devices the time intervals for sound ranging can be read from the phonic chronometer immediately the impulse is received, but the calculation of the position of the source is very troublesome. One way of avoiding this was devised by Captain A. Anderson, and consists of using glass or celluloid sheets with a series of circles drawn on them. If the positions of the receivers are marked on a plan and the observed time differences are converted into distances struck off as circles with compasses round two of the receivers, the source should be at the centre of a circle passing through one station and touching the other two circles, and by moving the glass plate over the plan the required circle can be found and its centre marked.

Another device, due to the author, is called a sound-ranging locator. Three or more receiving stations may be used and marked on the plan. At one of these points a long parallel bar is pivoted, and a number of thin steel bands are attached to the end of this bar, and to graduated rods running through swivelling slides fixed at each of the other stations. These strips can be adjusted by screws at the end of the bar (like the tuning arrangements of a stringed musical instrument) and clamped so that the distance from the clamp to the zero of each scale is exactly the same as the distance from the clamp to the point of the bar. A slide is provided on the bar with a vertical slit through which the strips all pass. When a record is obtained, the scales of the rods are set to the time differences obtained from the chronometer, and the bar is rotated and the slide pushed along the bar till all the strips are taut. When this is the case the edge of the slit from which the strips radiate is over the source of disturbance, and a pricker enables this point to be marked on the plan. In order to avoid the errors due to stretching of the strips by tensions introduced by pushing up the slider, a simple tension indicator is provided in each strip, and the slider is pushed up until the strips are all at the standard tension at which they are adjusted.

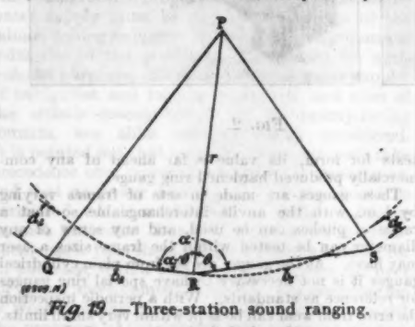

Fig. 19.—Three-station sound ranging.

An instrument on the same principle appears to have been devised by Mr. H. M. Dadourian in the United States under the name of the phonotelemeter, and was mentioned in the *Physical Review* for August, 1919, but was unknown when this instrument was designed, and no details have been obtained as to its construction.

By aid of this chronometer and locator it will probably be possible to determine the position of a source within a minute after the arrival of the impulse. Corrections have to be applied for the temperature of the water, which considerably affects the velocity of propagation, but these can easily be made by curves correcting the time differences observed to a standard temperature before setting them on the scales of the locator.

Detection and Location of Obstacles.

If a ship can locate its position in any weather, and guide itself to a harbour or through a channel in a fog, the only remaining danger is from obstacles such as icebergs, wrecks and rocks. It appears probable that the echo methods of detection already described will eliminate this danger, and echoes have frequently been obtained from ships, rocks and ledges, piers and other obstacles both by sonic and by high-frequency acoustic methods.

In 1917 Fessenden appears to have obtained echoes from ships, rocks and icebergs, using his oscillator described in a previous section, but this device is nearly non-directional owing to the relatively low frequency employed (about 1,900 ~ per second). It is, however, very powerful, so that when no disturbing obstacles are present good ranges should be obtainable.

High-frequency acoustic methods have given very good echoes with sharp directional indication on ships and rocks, but it is not yet known how far they will be successful with icebergs. These latter present special difficulty, as the elastic properties of ice do not differ so greatly from those of water as to gave a high percentage of reflection, but from calculations already made it appears probable that icebergs of any moderate size will be detected and located without great difficulty. Probably the most reliable arrangement will be a combination of an acoustic device such as the Fessenden oscillator or Wrighteon syren with high-frequency searching equipment.

Another device which may be of considerable service in navigation is the obtaining of soundings by echo methods from the bottom. This has already been carried out very successfully by M. Marti, who has obtained soundings in depths of from 60 m. to 160 m. to an accuracy of about a metre, from ships moving at speeds up to 10 knots, by the use of small explosive charges fired alongside the vessel. By this means valuable information as to position may be obtained and the approach to shoals or shores detected. The lecturer has recently devised a scheme for giving direct and continuous indication of the depth of water under a ship by a pointer indicator on the bridge.

A great deal of work has been done on submarine and aerial signalling both secret and otherwise, with the object of permitting ships to communicate with one another and thus avoid collisions.

One of these devices which may be mentioned is the improved form of photophone invented by Dr. A. O. Rankine and described before the Physical Society, in which a mirror is fixed on the lever of a phonograph diaphragm which forms an image of a bright illuminated grid on another similar grid. The amount of light transmitted varies with the vibration of the diaphragm and is concentrated on a selenium cell at the distant station. Remarkably clear speech is obtained in this manner and the device is easily adaptable to ordinary ship searchlights.

If all the above devices prove as successful as they appear to promise, it seems probable that before long the last remaining dangers will be eliminated from navigation, and that passages will be made without danger or delay in all weathers.

IV.—General Scientific Research.

We now come to the last section, dealing with fundamental scientific research. The great importance of a thorough knowledge of submarine physics, and especially of the transmission of disturbances of every character through the sea, has already been insisted on. Although a considerable amount of knowledge was gained during the war in the course of experimenting with various detectional devices, it was naturally of an incomplete and disconnected character. Immediately after the Armistice, however, the lecturer urged the importance of attacking these problems, before concentrating again on the detectional methods and devices which depend upon them, and the work at Shandon has been directed largely with this object.

The chief fundamental questions to be settled are the laws of propaganda of acoustic, electromagnetic, and optical waves in the sea. In addition it is most necessary to have methods of measuring the absolute values of the energy, &c., transmitted and received, and for investigating the properties of various transmitters and receivers.

Acoustic Research.—Even during the war valuable information was obtained in this direction under the guidance of Professor W. H. Bragg. The method of submarine sound ranging developed by him enabled much more precise measurements of the velocity of propagation of sound in sea water to be made than had been done formerly, and this value may be taken as 15,120 m. per second at 16·7 deg. C. from the measurements of Captain Boulding, as compared with about 14,500 m. per second for fresh water. The variation of velocity with temperature, which is probably somewhat high, has not yet been determined, but experiments are in progress at Shandon.

The phenomena of reflection are frequently most embarrassing as they give rise to interference effects. If a source of sound or other vibrational disturbance P (Fig. 20) is situated beneath the surface, the waves produced by it are reflected at the surface, so that at any point, Q, the effect is that which would be produced by two sources P and P′, the latter being the mirror image of the former. Owing, however, to the half wave-length retardation which takes place at reflection of a free surface, these two sources are in opposite phases, so that as the disturbances from them to any point at the surface of the water are equal, their effects will cancel and no sound should be heard. As a matter of fact a most powerful submarine explosion is very little heard on a ship half a mile away, and what is heard may be caused by the deformation or breaking of the surface by the explosion, although this phenomenon may have another interpretation.* On the other hand if the point Q is in such a position that the two distances PQ and P′Q differ by half a wave-length, the disturbances should arrive in the same phase and reinforce one another. There are therefore a series of hyperboloidal shells surrounding the source in which the sound is a maximum or zero, and if the source is near the surface there will be a large "dark" space near the surface where the intensity is very low. Experimental evidence of these interference phenomena was obtained by Dr. A. B. Wood and Dr. F. B. Young at the Cullaloe Reservoir in 1917, and they require the most careful study because, since most listening has to be conducted within a few feet of the surface and a submarine may frequently be running only at periscope depth, they may very greatly increase the difficulty of hearing.

During the past year considerable development has been carried out on the metrical determination of sound intensities by Messrs. B. S. Smith and G. F. Partridge at Shandon. As a standard source of sound they use a transmitter excited by a high-alternating voltage derived from a valve oscillating set which produces sound waves of known amplitude. The received intensity can be observed by a standard receiver connected to a three-valve resistance amplifier and a thermo-galvanometer. Potentiometer methods of measuring the amplification have been devised. Up to the present these methods have been employed chiefly for determining the characteristics of various forms of receivers, and Fig. 21 shows the variation of the potential difference developed by a magnetophone for different frequencies, for a constant

* The eleventh Kelvin Lecture, delivered before the Institution of Electrical Engineers, April 15, 1920.

† See paper on "Scientific Signalling and Safety at Sea," by Professor J. Joly, F.R.S., *Philosophical Magazine*, July, 1918.

* Professor Joly, however, claims that the sound from a submarine bell can easily be heard on a boat at a considerable distance.

amplitude of the standard source. This curve strikingly shows the selective properties of the receiver owing to the natural frequency of its diaphragm, and illustrates how such a receiver may modify or "colour" the nature of the sound received.

The lecturer has proposed to extend these methods for a complete investigation of the transmission and reflection of sound in the sea, but to employ the alternating-current potentiometer for the measurements, as this determines both the magnitude and phase of the disturbance. As this potentiometer will make measurements at a frequency of 1,000 ~ per second to within 0·0001 volt, and within 0·1 or 0·2 degree of phase, it is particularly suitable for the purpose. At this frequency 1 degree of phase displacement corresponds to a time difference of 1/360,000th of a second, so that 0·2 degree corresponds to about one two-millionth of a second, and the time required for an acoustic wave to travel only one foot can be determined to about one part in 400 or closer. By using a standard transmitter of spherical form, and employing the potentiometer in conjunction with a receiver and resistance capacity amplifier, measurements can be accurately made over short distances, and therefore be carried out for a preliminary investigation in a moderate-sized tank without serious trouble from bottom and side reflections, which can be practically eliminated if necessary by suitable acoustic lagging. In this way temperature changes can be conveniently studied. For longer range work the Gareloch is remarkably suitable on account of its sheltered position and fair width and depth, though to obtain service conditions deep open sea is essential.

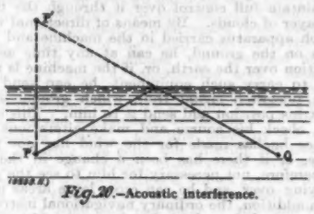

Fig. 20.—Acoustic interference.

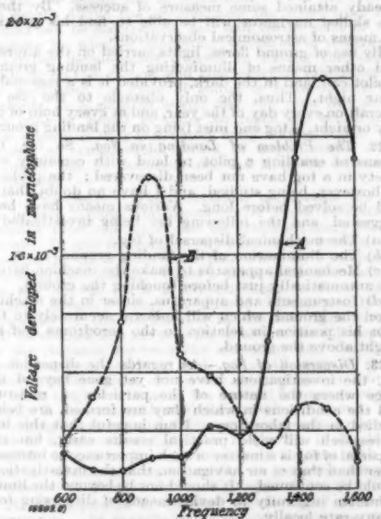

Fig. 21.—Calibration curves for air-drive magnetophone connected in line with a single 4,000-ohm ear-piece. Constant voltage of 800 volts at source, corresponding to a maximum amplitude of $2{\cdot}74 \times 10^{-4}$ cm.

Curve A.—Natural frequency of magnetophone reed; about 1,300 in air.
Curve B.—Natural frequency of magnetophone reed; about 600 in air. Hydrophone at 2 cm. from source.

Electromagnetic propagation.—The importance of this research, on account of the high absorption of sea water, has already been emphasised, and a good deal of preliminary investigation has already been done on it. On first joining the staff of Parkeston Quay in January, 1918, the lecturer made approximate measurements to ascertain the effect of absorption on the E.M.F. induced in a search coil lying on the bottom, in the middle of a rectangular loop 300 × 200 yards wide, laid in the mouth of Harwich harbour in about 20 ft. of water. These measurements were made by means of a galvanometer and rotating commutator on board a moored ship from which alternating current was supplied to the loop, and showed that at frequencies from 10 to 20 ~ per second the loss of E.M.F. by absorption was only 10 to 20 per cent. The position of the loop was located by a search coil and telephone with amplifier similar to the arrangement afterwards employed for the aural leader gear. These tests were sufficient for the immediate purpose, but as soon as the leader gear experiments were commenced in the middle of the year, certain phenomena connected with it led to further investigation of the magnetic field surrounding the cable at sonic frequencies, with the result of discovering that this field was nearly horizontal at moderate distances from the cable, instead of nearly vertical as would be anticipated from the ordinary theory. When the visual leader gear was proposed, it was anticipated from the small amount of absorption found at sub-sonic frequencies that the distortion would also be small, but experiments soon showed that this was not the case, and a series of field disturbance tests were made by means of the inclined coils on H.M.S. "Auricula" at various frequencies from 10 to 50 ~ per second showing large distortion which increased as the frequency was raised (see Fig. 17). In this connection it should be noted that the direction of the lines of force indicated on the diagram is only approximate near the points where the field is horizontal, as by connecting the coils in series it was possible to estimate the relative phases of the electromotive forces in the two coils, from which it appeared that the field was of an elliptically rotating character in this region. It must not be forgotten that these experiments were conducted on an iron ship, but the coils were so large and high that it is not probable that very serious distortion was caused by the hull. A mathematical investigation indicated that the effect was most probably due to the "skin effect" in the water, which caused the return current from the end of the cable through the sea to crowd in upon and over the cable, and also to refraction of the electromagnetic waves on escaping from the sea into the air.

Preparations are now nearly completed at Shandon for a rigorous experimental investigation of this phenomenon, as it does not appear that it can be completely solved mathematically. For this purpose a wooden barge is being equipped with a tall wooden mast, to the upper and lower ends of which a pair of horizontal and vertical search coils are fixed for determining the two components of the magnetic field (Fig. 22). The mast can be raised and lowered by a cord and winch so that the two upper coils can be fixed at any desired height above the surface, and the two lower ones at any depth beneath it. In addition a long horizontal spar with electrodes at its ends is attached to the bottom of the mast, and leads brought along it which as well as the connections from the four search coils are brought into a multicore cable running to an observing hut on Shandon pier. This pier contains an alternating-current potentiometer which will measure the amplitude and phase of the E.M.F. induced in the search coils and of the potential difference between the electrodes which is proportional to the current density in the sea.

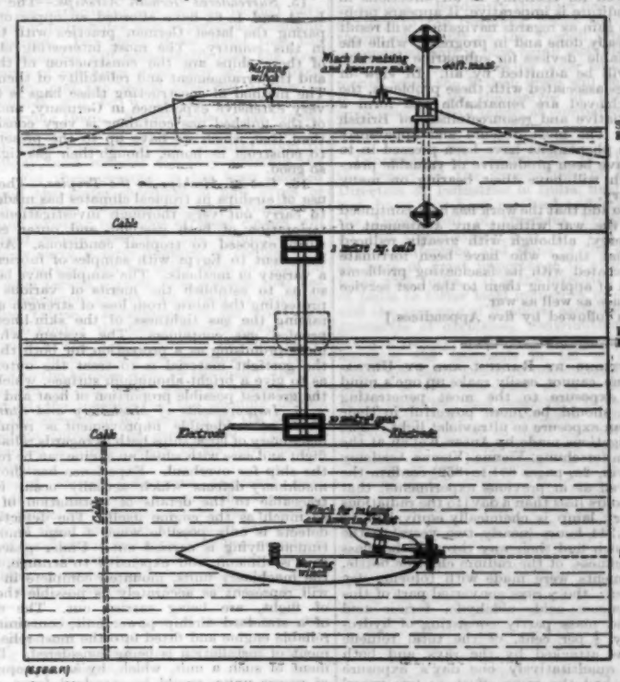

Fig. 22.—Arrangements for field and current distribution tests round submarine cable.

The cable is laid for a distance of about 2 miles along the loch as straight as possible and about 300 yards from the observation hut. At a point directly opposite the pier a junction box is inserted containing a 0·01-ohm resistance, the potential terminals of which are connected through a two-core cable to the potentiometer. This enables the magnitude and phase of the current to be determined in the portion of the cable where the measurements are being made, and eliminates the effect of attenuation, which may be of importance at the higher frequencies of 1,000–2,000 ~ per second up to which it is proposed to carry the observations.

It is, of course, necessary to be able to keep the barge in a definite position relatively to the cable when observations are being made, and for this purpose a 700-yard rope is run from the pier to a mooring in the Gareloch, and this rope passes over a winch drum on the barge, so that it can be warped along the rope into any position as in canal haulage. In calm weather it is hoped that this device will be effective. Ranges will be taken by a 9 ft. Barr and Stroud range finder installed in the observation hut.

In connection with these tests a second series of observations will be made on the electromagnetic field produced by circular and square coils when submerged. This is not only of great theoretical interest, but has an important bearing on the question of electromagnetic detection.

Appendix 3 gives an outline of the mathematical treatment of the subject, and a table of absorptions of plane electromagnetic waves of various frequencies is attached. For the purpose of this calculation a reliable determination of the specific resistance of sea water was required, and a Kelvin double-bridge arrangement was devised for the purpose. The measurements were carried out by Mr. H. Rivers Moore and gave a specific resistance of 27 ohms per cm. cube for water from Harwich Harbour mouth, and of 24 ohms per cm. cube for open sea water off Weymouth, with a temperature coefficient of — 3 per cent. per degree Centigrade in each case. These values were found to be independent of current frequency and dimensions over wide limits. The table of attenuations has therefore been circulated for a specific resistance of 25 ohms per cm. cube.

Another point of great interest is the existence of electrical currents in the sea due to tidal and wave motion in the earth's magnetic field, which were predicted by Faraday and have been experimented with by Dr. F. B. Young. These require investigation, as their behaviour is complicated by the nature of the channel or sea bed. It is possible that their elucidation may have important consequences in relation to submarine telegraphy.

Optical transmission.—Little work other than of an immediately practical and empirical character appears to have been done in this direction. It seems desirable, however, to have definite data concerning the optical absorption of sea water for various wave-lengths, and photometric arrangements are being made to determine it. There are, of course, numerous other problems of a detailed character which have been dealt with, or which require solution, but these are of comparatively little general interest.

Testing and training of observers.—Apart from the improvement of detectional devices, there is the observational element to be dealt with, particularly in the case of acoustic detection and direction finding in which great differences are found between the discriminating and binauralling facilities of different individuals. A large amount of work has been done in the training of listening officers at the Hydrophone Station at Portland, but investigations are being made with the object of obtaining metrical data as to the acoustic and visual facilities of observers, particularly as regards colour vision.

Conclusion.]

Although this account is somewhat long, it has not touched on the vast amount of work which has been done at the developmental Naval stations at Portsmouth and elsewhere. Great advances in radio-telegraphy and telephony and in the design of thermionic valves and amplifiers have been made at the signal school, and equally important developments in mining and torpedo construction and investigation have been made by the mining school and torpedo stations, all under the "Vernon." Of great importance in another direction is the work carried out at the Admiralty Physical Laboratory

at Wormwood Scrubbs under Professor J. C. McLennan, late scientific adviser to the Admiralty, which has resulted in the production of large quantities of helium gas for airships at a moderate cost. This may have a very important effect on the construction of glow lamps and thermionic valves.

Mention must also be made of the important work carried out by the Admiralty Compass Department at Slough, particularly in the development of the gyro compass which is of such great importance for submarine and general navigation, and as regards special compasses for aircraft.

As regards the future, as soon as the above-mentioned fundamental researches on transmission for which the Gareloch is specially suitable are completed, which will take about a year, the Shandon experimental station will be transferred to a new Admiralty physical laboratory to be built close to the National Physical Laboratory at Teddington, the sea experiments being conducted at Portsmouth or elsewhere. The general direction of scientific research at the Admiralty is now in the hands of the new Director of Scientific Research, Mr. F. E. Smith, F.R.S., who is co-ordinating the pure scientific research and experimental work with the developmental work of the existing Naval stations. It is hoped in this way to obtain the maximum of efficiency and co-operation without undue overlapping.

Although the need for economy in all directions in Government expenditure is imperative, it appears probable that immense gain as regards navigation will result from the work already done and in progress; while the need for really reliable devices for submarine detection and destruction will be admitted by all. In view of the great difficulties associated with these problems, the results already achieved are remarkable and form a tribute to the initiative and resourcefulness of British scientific workers. The most obscure and apparently academic scientific phenomena have been pressed in to the service, and have been productive of valuable practical results, which will have their bearing on many branches of industry.

It only remains to add that the work has been continued since the end of the war without any abatement of enthusiasm or energy, although with greatly reduced numbers; and that those who have been fortunate enough to be associated with its fascinating problems are keenly desirous of applying them to the best service of the nation in peace as well as war.

[The lecture was followed by five Appendices.]

Chemical Reactions by Radium and by Ultra-violet Light.—One cannot easily make up one's mind *a priori* whether exposure to the most penetrating γ rays of radium should be more powerful in their chemical effects than exposure to ultraviolet light. The most recent investigations made by Anton Kailan at the Institut für Radium forschung, Vienna (Vienna Academy Berichte, vol. cxxviii, 2a, pages 831 to 852) confirm the view, he had arrived at in previous experiments, that an exposure of 22 hours (less than a day) to the radiations of a quartz-mercury lamp is chemically equivalent to an exposure for 16,344 hours (nearly two years) to the rays of radium, which find their way through the glass wall, 1 mm. in thickness, of the radium chloride bottle. The recent experiments were made with toluene, dry or mixed with water; the γ rays converted part of this substance into benzoic acid, aldehyde, formic acid and some semi-fluid mass partly consisting of hydrocarbons. But only $\frac{1}{4}$ per cent. of the total toluene (100 grammes) was attacked by the rays, and both qualitatively and quantitatively one day's exposure to ultraviolet rays had the same effect as two years' exposure to radium radiations. Thus the light proved 700 times more powerful than the radium rays: the result is rather surprising, but one does not quite know what basis of comparison one should adopt.

Amplification of Electric Currents in the Bunsen Flame.—When two platinum wire electrodes are so held in a Bunsen flame as to be equally heated, the potential gradient between the two is by no means uniform. There is a very large drop of potential close to the cathode, where negative ions are deficient in numbers. When some salt, or merely a drop of sealing wax (which contains lime), is placed on the cathode (Wehnelt cathode), this electrode emits electrons, the gradient becomes uniform and the current through the flame is much intensified. If we could regulate the electron emission, we might amplify the current at will. This regulation can be effected, as in thermoionic valves, by placing a third grid electrode (simply a third wire) between the two wires. Experiments with such valves are described by C. W. Heaps, of Houston, Texas, in the *Physical Review* of last September. The grid, which is in circuit with its own small battery, should be kept clean of lime particles, which the convection currents in the hot flame would carry upward. Heaps, therefore, first mounted three parallel horizontal wires in the flame, the cathode on the top, the grid 1·5 mm. below it, and the anode, joined to the main battery, 3 mm. below the grid. To make the device more efficient he bent the tip of the cathode wire bearing the speck of lime upward and surrounded this tip by a real grid, a spiral of platinum wire. In this way he was able to amplify the current about 100 times by the aid of powerful gas flames, and he found that the lag involved in closing or breaking a circuit in the flame, by means of a key in the outer circuit, did not exceed 0·019 sec. But the current outputs were small, and gas flames are not so easily kept quite steady as the filaments in lamp valves. Thus the gas-flame valve seems little likely to replace the ordinary thermoionic valve, though it can serve as a delicate wave detector, for instance.

THE PRESENT POSITION OF AIRCRAFT RESEARCH AND CONTEMPLATED DEVELOPMENTS.*

By Air Vice-Marshal Sir E. L. Ellington, K.C.B., C.M.G., C.B.E., Director-General of Supply and Research.

(*Concluded from page 505.*)

14. *Rigid Airships.*—It was mentioned at the beginning of this lecture that during the war the rigid airships constructed in this country were copies of German Zeppelins. Two airships are now approaching completion which depart from the well-established German practice. The respect in which these ships differ from German practice is mainly in the construction of the hull. The structure is one of such great complexity that calculations in connection with it are extremely difficult, and developments in the design are, therefore, attended with very great interest. The size of R. 80, one of these ships, was necessarily restricted by the dimensions of the construction shed of Messrs. Vickers at Barrow, and an attempt has been made to give the ship considerably higher speed than that attained by earlier ships. R. 38, the second referred to, is essentially a larger ship than has been previously constructed in England.

15. *Surrendered German Airships.*—The surrender of L. 71 and L. 64 have afforded an opportunity of comparing the latest German practice with that followed in this country. The most interesting characteristics of these ships are the construction of their gasbags, and the arrangement and reliability of their machinery. The method of constructing these bags is the result of very extensive experience in Germany, and the weight of the finished gas container is very considerably less than that which we have up to the present been able to construct at home, though their gas tightness is not so good.

16. *Use of Airships in the Tropics.*—The anticipated use of airships in tropical climates has made it desirable to carry out very thorough investigations of the deterioration of both gastight and outer cover fabrics when exposed to tropical conditions. An officer has been sent to Egypt with samples of fabrics proofed by a variety of methods. The samples have been prepared so as to establish the merits of various methods of protecting the fabric from loss of strength and of maintaining the gas tightness of the skin-lined or rubber proofed gas containers. The system which appears most promising as a protection for both the fabric and the gastight material is to treat the outer surface so as to give a bright aluminium surface, which will reflect the greatest possible proportion of heat and light.

17. *Improvements of Machinery and Standard Power Units.*—Considerable improvement is required in the machinery of large ships both as regards reliability during flight and ease with which an engine can be removed from the ship for overhaul. Experience has shown that the machinery defects which actually occur in flight are traceable to the details of installation of the engine as much as the engine itself. The detection of these defects is only possible when a large amount of continuous flying is carried out. Under peace conditions this is difficult and expensive to arrange, and tests of the machinery units, mounted complete in a way that will represent as accurately as possible the conditions of flight, are being carried out. The development of a standard airship power unit, containing the most reliable engine and fitted into the most reliable arrangement of installation is being considered. The development of such a unit, which, by an appropriate number of power units, would be standard for a considerable number of ships of varying size is a valuable line of development.

18. *Use of Diesel Engines for Airships.*—The possibility of employing the Diesel, or a similar cycle in the engines of aircraft has already been mentioned. The permissible weights in an airship engine are at present greater than in aeroplanes, and are sufficient to admit of the ample proportions necessary for the heavy load involved; consequently, the first use of Diesel engines for aircraft will probably be made in an airship. The resulting economy in fuel will be of very great value in increasing the range of aircraft and their useful carrying capacity.

19. *Recovery of Water from Exhaust.*—The recovery of water from the exhaust of the engine is a matter of great importance for airships. An airship when making a flight of considerable distance burns a large weight of petrol, and it is necessary to discharge a corresponding amount of gas in order to maintain the equilibrium of the ship, unless a weight equivalent to that of the petrol burnt can be acquired by the airship. Successful experiments on the condensation and separation of this water have been carried out, but there are many difficulties to be overcome before a satisfactory solution is arrived at.

20. *Mechanical Handling Appliances.*—One of the greatest disadvantages of airships has been, hitherto, the necessity of returning an airship to the shed after each flight. This cannot be done in high winds, and at other times requires the assistance of a large landing party. To overcome these disadvantages, a series of experiments were carried out last year in mooring airships to a specially-designed mast. These experiments have proved that an airship can remain at the mast-head in all conditions of weather without damage other than that due to the deterioration of the fabric when exposed to sun, rain and wind. They have also proved that a skilful captain can bring his airship to the mast-head in light airs with the assistance of only some six men. A more complete design of mast than that used for these experiments has been developed, and one is about to be erected at Howden which will be fitted with lifts, properly controlled hauling arrangements and permanent petrol, gas and water mains. With this mast it is expected that the operation of mooring, even in bad weather, will be possible with the assistance of quite a small landing party. Should the mooring of airships prove satisfactory, it will only be necessary to return the airships to their sheds for purposes of important repair and overhaul. It must, however, be possible to take ships into their sheds with a considerable wind blowing across the mouth of the shed. For this purpose handling rails are being installed at Howden, which will allow the airship to be supported against the cross-wind forces by trolleys running on railways, and to which handling guys of the ship are attached.

21. *Navigational Instruments and Apparatus.*—The improvements made in seroplanes, seaplanes and engines during the war in the way of performance and control, have made aircraft capable of flying in any normal weather conditions provided the atmosphere is sufficiently clear to enable a pilot to avoid obstacles when taking off and to land with safety. Once the machine is in the air, an experienced pilot, by means of turn indicators, compasses, air speed indicators and other instruments provided, can fly this machine on any course he wishes and maintain full control over it through the thickest fog or layer of clouds. By means of directional wireless telegraph apparatus carried in the machine and beacon stations on the ground, he can at any time ascertain his position over the earth, or, if the machine is not big enough to carry such equipment, he can send out a wireless telegraph signal from which ground stations can plot his position and send it to him. This enables him to check his course and make alterations if the allowance he has made for the wind has not proved accurate, or if there has been a change in the wind. It is, therefore, not necessary for him to see the ground he is flying over, and he can cross large areas of open sea. In addition, the ordinary navigational instruments used at sea are being adapted to use in aircraft, and have already attained some measure of success. By these, the skilled navigator will be able to find his position by means of astronomical observations.

By use of ground flares, lights carried on the aircraft, and other means of illuminating the landing ground, a pilot can land in the dark, provided it is a reasonably clear night. Thus, the only obstacle to the use of aircraft on every day of the year, and at every hour of the day or night, is fog and mist lying on the landing ground.

22. *The Problem of Landing in Fog.* So far, the means of enabling a pilot to land with certainty and safety in a fog have not been discovered; the problem is, however, being studied, and I have no doubt that it will be solved before long. Various means have been suggested, and the following are being investigated:

(*a*) The mechanical dispersal of fog.
(*b*) The illumination of the landing ground.
(*c*) Mechanical apparatus to make the machine flatten out automatically just before touching the ground.
(*d*) Instruments and apparatus, either in the machine or on the ground, which will indicate accurately to the pilot his position in relation to the aerodrome and his height above the ground.

23. *Dispersion of Fog.*—As regards the dispersion of fog, the investigations have not yet gone beyond the stage where the nature of the particles of moisture and the conditions in which they are formed, are being studied in the laboratory. I am hopeful that this line of research will yield practical results early, but the dispersal of fog is a matter of such importance to interests other than that of air navigation, that the investigations should be continued. It should not be beyond the limits of human ingenuity to devise means of dispersing fog, at any rate locally.

24. *Illumination of landing grounds.*—The illumination of the landing grounds in misty weather sufficiently to enable a pilot to land is practicable up to a certain degree of mistiness. The method is the same as that used for night landing where the ground itself is lit up, either by petrol flares or by powerful lamps. These are arranged in such a way that the pilot knows where to land and in which direction. The machine itself is provided with wing-tip flares which can be lit up by the pilot on approaching the ground. These can be used to supplement the ground flares, or to provide light in the event of a landing on unilluminated ground, as, for instance, in the case of a forced landing. Since the flares once lit cannot be put out and re-lit, should the pilot find the place unsuitable for landing and wish to try elsewhere he would have to make his second attempt without the aid of these lights. Consequently, a system of powerful electric lamps carried on the wings is being developed in substitution of the wing-tip flares, so that a pilot can switch on and off as required. For misty weather, flares and lights of different colours which give a better penetration than ordinary white light are being tried, and it seems probable that red or orange flares and lights will increase the degree of mistiness in which a landing is practicable by their means.

25. *Mechanical Landing of Aeroplanes.*—The attempt to provide mechanical means of landing the machine automatically has arisen in the following way. The gliding angle, or the angle at which a machine descends, is known for every type of machine, and also the speed at which it should travel through the air when descending at this angle. Instruments in the machine can show the pilot whether the machine is in fact at this angle and flying at the required speed. If, therefore, it can be indicated to a pilot approaching that he is at a definite number of feet above the aerodrome, and if also it can be indicated to him the direction in which he should fly

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* Paper read at the Air Conference, London, October 13, 1920.

in order to land within the aerodrome, he has only to throttle down and put the engine at its gliding angle at the right time to reach the ground where a landing is possible. Since fogs usually occur in still air, and when lying on the ground do not extend upwards more that a few hundred feet, it should be possible by means of a line of balloons flying above the fog with the height marked on them to tell the pilot both his height and the direction he should fly. As you all know, a machine about to land has to flatten out just before reaching the ground, and when the pilot can see the ground, he judges the right time by eye. In order to provide automatically for this flattening out, an aeroplane was fitted at the Royal Aircraft establishment with an attachment called a Noakes' ground indicator. It consists of an arm extending below the fuselage and attached to the controls. When this arm touched the ground, the controls were moved and the machine flattened out. A number of successful landings were made by this means. As machines on landing are inclined to bounce, a tail skid, known as the Palethorpe tail skid, has been designed with a buffer and spring which are compressed on the tail first touching the ground, and then by the resulting expansion presses the tail upwards and thereby assists in damping out the bouncing and in keeping the wheels from leaving the ground once they have touched.

26. *Methods of indicating to a Pilot his Height above the Ground.*—There are two methods now under investigation for indicating to the pilot his exact height above the ground and his position with regard to the aerodrome. The first makes use of the sound given out by the engine. A number of microphones are provided arranged symmetrically over a considerable area. Means are provided by which the microphone only receives the sound of the engine when the machine is passing through the cone of the atmosphere at the apex of which the microphone is located. The time taken by the machine between entering one cone and entering the next gives the speed over the ground, observations from a number of instruments whose position is known give the direction of flight, and from the speed, and time taken to traverse completely a cone and the angle of the cone which is known, the height can be calculated. Thus the course, the height above the ground, and the speed over the ground can be ascertained, and sent to the pilot in the machine by wireless telegraphy, telephone or telegraph. A further development consists in having the sound producer on the ground and the receiving apparatus in the aeroplane. A cone of sound is formed, directed upwards at a suitable angle, and the pilot flies down this cone of sound in order to reach the aerodrome. This system is only in its very early stages, and it will require a considerable period of experimental work before it can be definitely decided that the scheme is practicable.

27. *Proximeter.* When electrical oscillations are set up in any circuit, the frequency of these oscillations depends *inter alia* upon the electrical capacity of the circuit. In this instrument two conducting surfaces are fixed on the under sides of the planes and have a capacity effect between them. When a third conductor such as the sea or wet earth is brought near to them, their mutual capacity effect is altered. Consequently the frequency of the oscillations in the aeroplane circuit will be altered and the amount of alteration will depend on the distance between the aeroplane and the third conductor (wet earth or sea). A small lamp in series with an independent circuit can, by suitable couplings, be made to glow whenever the natural frequency of this circuit is in tune with the one mentioned above. By arranging a series of such lamps and independent circuits, each of which varies slightly in frequency, it should be possible to get each one successively in tune with the original circuit and consequently to get each lamp in succession to glow as the machine approaches the earth.

28. *Developments to Increase the Safety of Crew and Passengers.* As regards developments which are going on to increase the safety of the crew and passengers in aircraft, the two most important are those directed at the prevention of fire and the provision of parachutes. The chief danger is the catching fire of the fuel, either from coming in contact with the hot parts of the engine or from an accumulation of petrol and vapour within some part of the fuselage being set on fire by a spark from the magneto. A considerable measure of protection can be provided by efficient drainage to prevent the accumulation of petrol, and by the provision of a fireproof bulkhead separating the engine compartment from the rest of the machine, the object being to isolate the source of fire, i.e., the hot parts of the engine. A tank which will not burst and release the petrol in a crash would add to the protection. The placing of the petrol tanks away from the crew on the wings has advantages in such circumstances, and the provision of means for the rapid release of the petrol before landing when a crash is possible is another precaution. For military machines which are exposed to attack with incendiary bullets, special precautions are necessary, and these take the form of self-sealing tanks. These are made of thin sheet metal surrounded with a covering of rubber, of such a character that the hole made by the bullet is automatically closed by the expansion of the rubber surrounding the hole. These tanks have the disadvantage of being weaker than steel tanks, and entail a greater weight and bulk of tank than the ordinary steel one. So far as our experiments go to show, they do not stand up as well in a crash as the ordinary ones. In spite of these disadvantages, however, they have been generally adopted for war machines, since they provide considerable protection against one of the greatest risks to which the military airman is exposed.

Protection against fire due to sparks from the magnetos is being sought by making them fireproof, and the problem has been under investigation at the National Physical Laboratory and the Royal Aircraft Establishment for some months.

29. *Parachutes.*—The provision of parachutes is a controversial matter. The parachute enthusiast who has demonstrated time and again that a man can leave a machine in flight by means of a parachute with almost certain success, considers the provision of parachutes for all members of the crew an obvious precaution which should be compulsory on all civil and military machines. The opponent points out that though it has been demonstrated that a man can parachute successfully from a machine in flight and under control provided he leaves the machine at a sufficient height, it is doubtful whether this can be done when a crash is impending and the machine is out of control. Further, it is by no means certain that their provision will not lead to more accidents owing to the crew attempting to parachute and failing when a safe landing could have been effected. Moreover, a high proportion of accidents is due to loss of control which occurs so close to the ground that a successful parachute descent could not be made. From the military point of view, the additional weight and obstruction to the free movements of a pilot resulting from the provision of parachutes may affect the fighting qualities of a pilot and his machine to such an extent that his chance of being destroyed by an enemy will be greater than his chance of saving himself by parachute.

This matter cannot be settled by theoretical consideration and by experiment; it can be decided only by the provision of parachutes and experience extending over a long period. But there is no doubt that the provision of parachutes will occasionally save the lives of the occupants of machines when they are destroyed by enemy action, and the moral effect on a crew of having parachutes will be worth the disadvantages entailed by carrying them. Experiments so far carried out show that single and two-seater machines can be provided with parachutes which can be relied upon to function properly, and without seriously affecting the performance. For these reasons it has been decided that single and two-seater machines of new types of aircraft for R.A.F. use will generally be provided with parachutes and existing machines of these classes will be so equipped where possible. The equipment of machines which carry a large number of people with parachutes so that they can be relied upon to function properly for each person carried is a problem that has not yet been completely solved, but it will no doubt be solved in due course. Parachutes so far tried are generally of two kinds; the first is stowed away in the machine in such a way that it will be released automatically on the man leaving the machine, the cable being attached to the harness worn by the man; and the second is carried on the man, who, on releasing it, is blown out of the machine by the opening of the parachute in the current of air provided by the passage of the aeroplane through the atmosphere. The first class has reached a further stage in its development than the second.

30. *Mechanical Starters.*—Frequent accidents have taken place due to men when starting the engine by swinging the propeller, being struck by the propeller. The majority of these accidents are due to carelessness or disregard of instructions, but some have been accidents pure and simple. In order to remove the possibility of such accidents, mechanical means of starting aero-engines are being developed. These generally are of two kinds:—

(*a*) The starter which is no part of the machine, but aerodrome equipment.

(*b*) Starting devices which form an integral part of the machine and its engine.

Satisfactory apparatus of the first class can now be provided, and two patterns have been tried out successfully.

The design of a starting apparatus within permissible weights which forms part of the aeroplane or engine is a matter of much greater difficulty. Various methods of charging the cylinders and firing them by means of an auxiliary magneto have been tried without complete success. An auxiliary engine for this purpose is being tried which shows considerable promise of success. A 1½-h.p. engine is attached to the fuselage and provided with a hand starting device which can be operated by the pilot. This is connected to a pump which supplies the mixture to the main engine under a pressure sufficient to turn the engine slowly. This mixture is supplied from the same source as that used for driving the auxiliary engine, so that if the latter is working, it is known that the mixture is of the right composition of air and petrol. When the main engine is turning, the pilot switches on and the engine starts. The total weight of this apparatus is approximately 40 lb.

31. That, ladies and gentlemen, brings to a close my short survey of the position of aeronautical research, as it stands to-day. My endeavour has been to place the situation before the conference in a way that will appeal not so much to the specialist as to those whose study is the science of aviation in its widest sense; those, in fact, whose collective views represent what may be described as considered public opinion. It is in their hands that the future of aviation rests, inasmuch as progress is but a measure of a demand. During the war, the demand was so urgent that the progress made in the art of flight in four years was so rapid that it might be almost said to have eclipsed anything previously known on the history of science, and no praise would be too high for those whose efforts enabled this country to take so large a part in this achievement. As an instrument of war, aircraft has not only proved its value but promises to become a factor of ever-increasing importance. From a civil point of view, though the utility of aircraft has not been demonstrated to the same extent as it has in warfare and the demand is correspondingly less, there are few who would deny that aviation is destined to play an important part in the advance of civilisation.

The main object of this conference is to endeavour to place an estimate upon the rate at which progress may reasonably be expected, and in that scientific research holds the key to progress. I trust I have succeeded in placing my account of the present situation before you in a form in which it will prove to be of real assistance.

Claude Synthetic Ammonia Process.—Referring to a paragraph in the *Frankfurter Zeitung*, in which it is stated that "the French have realised that the Claude process is not altogether satisfactory, and desire to add small technical details as used in the Haber process," *The Board of Trade Journal* says that the Cumberland Coal Power and Chemicals, Limited, who are the owners of the British and Colonial patents of the Claude process, point out that this German statement is altogether erroneous. The French owners of the Claude process have not approached the German Badische Company for the right to use any part of the latter's process, and have no intention of doing so. The Claude process is working on a semi-commercial scale in an entirely satisfactory manner, and is securing, in three operations, what it takes the German Haber process eight operations to achieve. Evidently this fact has caused considerable anxiety to the Germans, hence their desire to try to throw cold water on the French process. A full-sized commercial unit is now being installed in France and is expected to be in working order before the end of next month when the British press will be invited to inspect it and judge for themselves of the great value and simplicity of the Claude, as compared with the German Haber, process.

Industrial Development in India.—Copies of the report of the proceedings of the Conference of Directors of Industries in India, held at Simla, in April last, have now been received and may be consulted at the Department of Overseas Trade, Inquiry Room, 35, Old Queen-street, S.W. 1. The subjects discussed at the conference, and some of the conclusions arrived at, were of great importance to everyone interested in trade with India. It is the intention of the Government of India to foster local industries in every possible way, and the granting of financial assistance in the form of a guarantee of dividends, contributions to share capital, loans of money, and agreements to purchase output, are amongst the proposals in aid of new undertakings. Steps are being taken to encourage in India the manufacture of machinery and other articles which are now being imported, and preference in the placing of orders for Government requirements will, where possible, probably be given to local manufactures. Of special importance to United Kingdom manufacturers was the decision of the conference to study the demand for machinery and engines with a view to standardisation and ultimate manufacture in India. A committee was also appointed to study the question of boilers and the possibility of the unification of existing laws and regulations for boilers throughout India. The labour question and the training of an industrial service were also fully discussed, and issues were raised of a very wide nature. Firms or individuals concerned in the Indian trade and likely to be affected by the industrial development of India, should study carefully this new movement, which is likely to have far-reaching effects on the trade of India with the United Kingdom.

Resistance of Metals to Pressure.—Compression strengths of metals being somewhat indefinite, Dr. A. Pomp made some tests on the shortening of cylinders, 10 mm. in diameter, 20 mm. high, gradually loaded up to 15 tons on an Amsler machine. The materials tested were: Lead; lead alloyed with 3 per cent. of tin; commercially pure, drawn and annealed copper; brass containing 62 per cent. of copper; aluminium; mild steel containing 0·06 per cent. of carbon; and steel containing 0·5 per cent. of carbon—all these metals being drawn and annealed. We give a summary of the results taken from the *Zeitschrift des Vereines Deutscher Ingenieure*, of September 11. Column A indicates the tensile strength in kilogrammes per square millimetre; B the same referred to the 0·5 C. steel = 100; C the pressure in kilogrammes required to produce a shortening of the cylinder by 10 mm.; D this pressure, again referred to steel = 100.

	A.	B.	C.	D.
Steel (0·5 C.) ..	54·0	100·0	13,050	100·0
Brass	46·0	85·0	11,480	88·0
Mild Steel ..	38·5	71·5	9,800	75·0
Copper	22·0	40·8	5,200	40·0
Aluminium ..	10·0	18·6	2,910	22·3
Lead-tin alloy ..	2·4	4·5	580	4·8
Lead	2·2	4·1	405	3·1

A comparison of columns B and D shows that the tensile strength and the compression strength, as measured by the shortening, run fairly parallel; but some of the other figures given in the paper are rather curious. Lead proved, of course, the most compressible material, and the addition of 3 per cent. of tin did not greatly affect the strength. The aluminium cylinder was reduced to half its height by a pressure of 2,910 kg., whilst it required a pressure of 5,200 kg. to produce the same result in copper. The mild steel was more resistant to compression than brass up to 6,000 kg., but less so for greater loads. The formation of cracks was not observed in any of the tests.

NOTE ON A FAILURE OF "MANGANESE BRONZE."*

By J. H. S. Dickenson, Member, Sheffield.

Some time ago the author had occasion to investigate the end-plate of a single-phase turbo-alternator rotor which failed by the intergranular fracture of several of the peripheral projections holding damping bars, the fractured surfaces very much resembling those characteristic of strongly overheated, or burnt, alloy steels, and being unaccompanied by any visible distortion.† The end-plate in question was made of cast "manganese bronze"—or manganese brass, to adopt the systematic nomenclature—having the following analysis, and the microstructure shown in Figs. 1 and 2, annexed: Copper, 55·75 per cent., zinc 36·77 per cent., manganese 3·87 per cent. aluminium 2·56 per cent., iron 1·30 per cent., tin 0·08 per cent., lead 0·07 per cent.

It was therefore a typical β brass of simple polyhedral structure, and bend tests taken a little distance away from the places where fracture actually occurred indicated the toughness and ductility characteristic of such material. The presence of solder on the surfaces of the projections, the appearance of a whitish tinge on the large granular facets of the fracture, and finally microscopic evidence of intergranular films penetrating from the surface and diminishing inwards (Fig. 1, annexed), indicated quite positively that the weakness of the metal had been produced either during the original soldering, or subsequently in service. Later evidence was forthcoming that local heating had occurred during running, and that fluid solder had penetrated between the grains of the "manganese bronze" end-plate while the latter was under stress, thus producing extreme local brittleness. Subsequently, a number of small bend test-pieces, each 10 mm. by 10 mm. by 80 mm., were prepared from the normal material in the body of the plate, and bent on a Vee block under a press. It was found that while such pieces would bend to a considerable angle, then tearing open and showing a tough fibrous fracture, whether tested at room temperature or as high as 200 deg. C., yet they collapsed instantly under very small loads, showing an intergranular fracture, and no appreciable distortion, if heated to, say, 200 deg. C. and touched with a stick of soft solder on the tension side. This effect could not be produced unless the solder were fluid at the moment of stressing, and test-pieces soldered all over bent normally, not only at room temperature, but at any temperature below the melting-point of the solder. The moment this was reached slight application of stress produced interangular fracture. It was further found that a test-bar could be coated with solder on the compression side, and would bend perfectly normally when heated above the melting-point of the solder. Obviously the tin-lead alloy could readily penetrate between the grains of β brass when they were under stress, tending to tear them apart, but not when they were pressed together in compression. It would further appear that there is an extreme readiness for the undercooled, amorphous cement between the crystalline grains to combine with the coating alloy, since intergranular fracture commences the moment the latter melts, and the merest trace of solder suffices to produce the effect.

Altogether this case presents a close analogy to the action of mercuric salts on brass tensile test-pieces mentioned by Dr. Rogers,‡ and the phenomenon of "season cracking" where, it seems probable to the author, some action takes place at the surface, possibly oxidation, but certainly requiring time, affecting the amorphous films at the grain boundaries, so that even under slight stress separation occurs.

Although the failure of the end-plate under investigation was thus satisfactorily explained, the author considered it desirable further to elucidate the conditions under which alloys of the manganese-bronze type are prejudicially affected by contact with fluid solder, the special points on which information was required being, first, the stress necessary to produce failure, and also to what extent variation in composition and microstructure affected the result. A number of experiments have been carried out, and a very condensed account of the results may, it is hoped, be of interest to the institute.

1. The samples selected for examination were two cast test-bars of "manganese bronze," a forged bar of "manganese bronze," and two samples of rolled brass, the analyses being as under:—

	O M B. As Cast.	F L. Forged.	H T. As Cast.	D. Rolled.	A. Rolled.
Copper	58·20	58·24	55·64	71·03	62·52
Zinc	37·44	35·57	38·64	28·56	36·30
Manganese ..	0·69	3·64	3·46	..	nil
Aluminium ..	0·10	0·80	1·32	nil	nil
Iron	1·30	0·50	0·90	—	0·21
Tin	1·16	nil	trace	trace	trace
Lead	trace	nil	nil	0·17	0·81

The samples O M B and H T were tested only in the condition as received, but portions of the forged "manganese bronze" bar F L were heated to 820 deg. C. and quenched in water, these samples being marked F L W Q, while test-pieces removed from the bars of D and A were annealed, with slow cooling, at 750 deg. C. and 800 deg. C. respectively, being then marked D A and A A. Photomicrographs at 50 diameters magnification of each of these samples are reproduced herewith, and show that D (Fig. 10, page 557) after annealing is a typical alpha brass with well-marked twinned crystals, while H T as received, and F L after water-quenching, are made up entirely of simple polyhedral β crystalline grains. O M B, as received, shows mixed α and β crystals, the same remark applying to F L in the forged condition. Higher magnifications are required to show that D in the rolled condition, as received, is composed of a constituent, and that A, in like condition, is principally α constituent with some β crystals.

2. Bend test bars from each of the above eight samples were examined under stress in contact with the metals A to D, of which details are given in the table on the opposite page.

Fig. 1.
Solder intrusion in Manganese Bronze End Plate. ×50.

Fig. 2.
End Plate further in. ×50.

Fig. 3.
"C" Alloy intrusion in β Brass. ×50.

Fig. 4.
"B" Alloy intrusion in α Brass. ×50.

Fig. 5.
FL. ×50.
Manganese Bronze F. as forged.

Fig. 6.
FLWQ. ×50.
Manganese Bronze F. as water-quenched.

(Reduced by about One-Eighth.)

The test bars, which were in all cases machined and finished on emery cloth to 10 mm. square and about 80 mm. long, were coated with one or other of these alloys by heating on a hot plate, and rubbing the middle portion, of one side only, until a thin fluid film about 0·01 in. to 0·02 in. thickness was obtained over the whole of the middle inch. A little "Coraline" soldering

* Paper read before the Institute of Metals, at Barrow-in-Furness, on September 16.

† Previously referred to by the author in the discussion by correspondence of Desch, "Solidification of Metals from the Liquid State," Journal of the Institute of Metals, No. 2, 1919, vol. xxii, page 274.

‡ Journal of the Institute of Metals, No. 2, 1919, vol. xxii, pages 114 and 115.

paste, which contains a little zinc chloride, was used to secure wetting. Care was taken to avoid heating the test bar higher than necessary just to melt the applied metallic coating.

3. An ordinary 3,000-kg. Brinell-hardness testing machine was used for bending the test bars, which were supported on the knife-edges 58 mm. apart. A thermo-couple was inserted between the asbestos insulated nichrome heating coil and the specimen, the deflection under load being measured by the movement of a spot of light focussed on a mirror, this being caused to turn by a pin pressed upwards by a counterweight to make contact with the middle of the tension, and lower side of the test-piece. This arrangement had the advantage that when specimens coated on the tension side were under test, the melting of the alloy could be instantly observed, and the pyrometer checked, by a considerable movement of the mirror in a direction opposite to that produced by loading. Table I (page 558) sufficiently indicates the programme of testing. From each of the eight samples, whose photomicrographs are given in Figs. 5 to 12, seven 10 mm. by 10 mm. test bars were prepared, four of these being coated, as indicated in the table, and tested in bending, with the coated side in tension, to give a load-strain diagram, while they were maintained at temperatures a few degrees higher, in each case, than the melting points of their respective coatings. The other three specimens were tested similarly, but without coating, while maintained at the room temperature, at about 105 deg. C., and at about 245 deg. C., respectively. In preparing the load-strain diagrams, the deflection was measured, to 0·0001 in., at each added increment of 50 kg. load. The period of the test naturally varied according to the stress attained, the rate being about 1 minute for each 100 kg.

FIG. 7.
HT. ×50.
Manganese Bronze as cast.

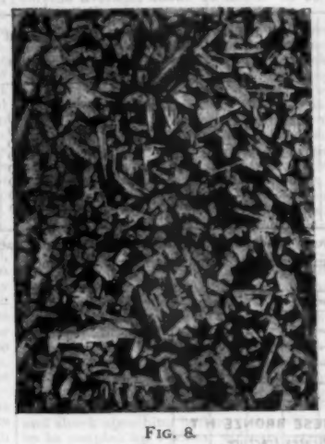

FIG. 8.
OMB. ×50.
Another Manganese Bronze as cast.

FIG. 9.
D. ×50.
Brass "D" as rolled.

FIG. 10.
DA. ×50.
Brass "D" as annealed.

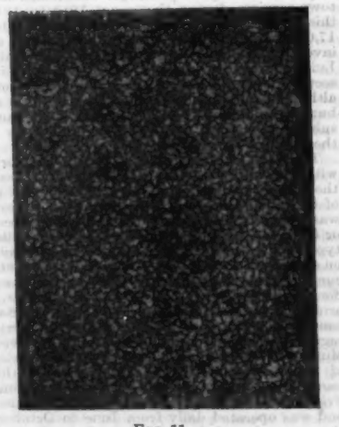

FIG. 11.
A. ×50.
Brass "A" as rolled.

FIG. 12.
AA. ×50.
Brass "A" as annealed.

(REDUCED BY ABOUT ONE-EIGHTH.)

	A.	B.	C.	D.
	per cent.	per cent.	per cent.	per cent.
Tin	13·5	25·0	63·0	100·0
Lead	27·5	25·0	37·0	—
Bismuth ..	52·0	50·0	—	—
Cadmium ..	2·0	—	—	—
Melting-point ..	69·5 deg. C.	93·0 deg. C.	182·5 deg. C.	232·0 deg. C.

Table I gives the maximum load attained, and the deflection reached, at the moment when the specimen broke, or, alternatively, was removed unbroken from the machine. The author would have wished to give the complete set of load-strain diagrams, but has been restrained by the necessity for economy in printing, merely giving the typical sets obtained from the "manganese bronze" H T, wholly of β constituent (Fig. A); from the 71 : 29 brass D, which is entirely made up of α crystals (Fig. B); and from the lower "manganese bronze" O M B, which contains both α and β constituents (Fig. C).

4. *Consideration of the Results.*—It will be noted that the behaviour of the different brasses when under stress in contact with fluid alloys varies with their micro-structures. While the two samples H T and F L W Q, made up of simple polyhedral grains of β brass, very easily collapse under small stresses when wetted with either tin or the other alloys tried, yet the α brass samples are much more resistant, the other specimens containing mixed α and β crystals occupying a midway position. It is curious to note that the α brass appears to collapse more readily under the action of the lower melting-point alloys, this being reversed in the case of the β brass for some reason which the author is at present unable to explain. It is also curious that in several of the series the variously-coated specimens collapsed at much the same load, but with greatly varying amounts of deformation. Thus, for examples, the four coated specimens of the mixed brass O M B all failed between 490 kg. and 500 kg. load, although the deflection of the moment of fracture varied between 0·022 in. and 0·042 in. Similarly, the four coated specimens of the α brass D all failed between 780 kg. and 870 kg. load, but with deflections varying between 0·048 in. and 0·203 in. The tendency is for the deflection to be greater, owing to the decrease in hardness of the specimen, as the temperature rises, but roughly the collapsing load is the same. This rather suggests that with rising temperature the strength of the crystalline grains falls more rapidly than that of the surrounding amorphous material, at any rate the author is unable to offer at present any more convincing explanation. Finally, it should be noted that although the α brasses withstood higher stresses, and showed far more deformation when under the action of fluid alloys than the β brasses, yet the fractures were none the less crystalline, as is proved by Fig. 4, which shows the B alloy (melting-point, 93 deg. C.) penetrating inwards *via* the α crystalline grain boundaries of the annealed 71 : 29 brass D A, stressed at 105 deg. C.

Fig. 3, page 556, shows the C alloy (melting at 182·5 deg. C.) penetrating between the β crystalline grains of the water-quenched manganese bronze F L W Q stressed at 195 deg. C. Microsections were removed from the cracked portions of most of the specimens, and invariably showed the same thing. In some cases, especially in the alloys containing both α and β crystals, and the fine-grained rolled brasses, it was very difficult to ascertain precisely how penetration occurred, and certainly in some cases the cracks occasionally proceeded through, instead of round, both α and β crystals. Still, on the whole, the tendency in both α and β is for the penetration of fluid alloys to follow the grain boundaries. This being so, the only apparent reason why the simple polyhedral β brasses should fail so much more easily lies in the absence of granular interlocking, a further example to show the danger of permitting metallic crystals to develop smooth and regular outlines.*

The author regrets that, owing to the pressure of other work, he has been unable to follow up this interesting subject in several obvious directions. Thus, it would have been useful to ascertain whether the α brass samples could have been caused to fail under the action of fluid alloys if less loads than those required in the present series of tests had been applied for longer periods of time. It seems probable that further work in this direction might throw additional light on the phenomenon of season cracking, and in any case it would have been interesting to learn whether samples of cold-worked brass, liable to develop "season cracking," would fail when immersed in baths of fusible alloy, just as when treated with mercuric nitrate. However, the danger of using "manganese bronze," made of the β constituent with a simple polyhedral structure, in electrical or other

* "Intercrystalline Fracture of Metals under Prolonged Application of Stress." Rosenhain and Archbutt, Proceedings of the Royal Society, A, vol. xcvi (1919).

"NOTE ON THE FAILURE OF 'MANGANESE BRONZE'" (TABLE I.)

Alloy.	Micro-Constituents.	Uncoated at Room Temperature about 16 deg. C.			Coated with "A" Alloy melting at 99·5 deg. C.			Uncoated at about 105 deg. C.			Coated with "B" Alloy melting at 93 deg. C.			Coated with "C" Alloy melting at 182·5 deg. C.			Uncoated at about 250 deg. C.			Coated with Tin melting at 232 deg. C.		
		Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.	Load in kilos.	Temperature.	Deflection.
			Deg.C.	Inch.		Deg.C.	Inch.		Deg.C.	Inch.		Deg.C.	Inch.		Deg.C.	Inch.		Deg.C.	Inch.		Deg.C.	Inch.
FL	α and β	1,250	..	0·563UB	760	73	0·049 G	1,150	..	0·512UB	600	102	0·017 G	650	185	0·034 G	850	245	0·480UB	650	245	0·056 G
FLWQ	β	1,230	..	0·295 D	300	75	0·010 G	1,220	105	0·307 *	320	104	0·006 G	200	195	0·005 G	900	245	0·547UB	150	245	0·003 G
HT	β	1,300	..	0·407 *	450	76	0·013 G	1,200	103	0·555UB	380	105	0·010 G	100	190	0·002 G	800	240	0·563UB	100	244	0·002 G
OMB	α and β	900	..	0·290 D	430	78	0·022 G	875	102	0·512 F	500	104	0·034 G	450	205	0·025 G	750	245	0·496UB	480	245	0·042 G
D	α	1,000	..	0·551UB	780	82	0·048 G	970	107	0·464UB	790	103	0·053 G	870	201	0·203 G	830	253	0·114 F	840	244	0·141 D
DA	α	500	..	0·43 UB	270	84	0·070 G	500	104	0·42 UB	280	105	0·064 G	390	203	0·250 G	440	250	0·46 F	410	248	0·200 G
A	α and β	1,170	..	0·555UB	800	79	0·031 G	1,120	103	0·472UB	940	103	0·067 G	1,030	211	0·210 D	940	249	0·169 F	940	245	0·163 D
AA	α and β	600	..	0·574UB	370	84	0·130 G	560	103	0·512UB	350	106	0·095 G	390	204	0·161 G	500	245	0·476UB	400	245	0·163 G

"UB" indicates "unbroken." "F" indicates torn, "fibrous" fracture. "G" indicates granular fracture. "D" indicates fracture not classified.
* Some surface cracking with an intergranular tendency.

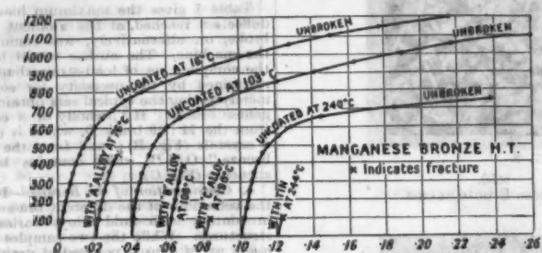

FIG. A. LOAD-STRAIN DIAGRAM, "MANGANESE BRONZE" "H.T." (CONSISTS WHOLLY OF β CONSTITUENT).

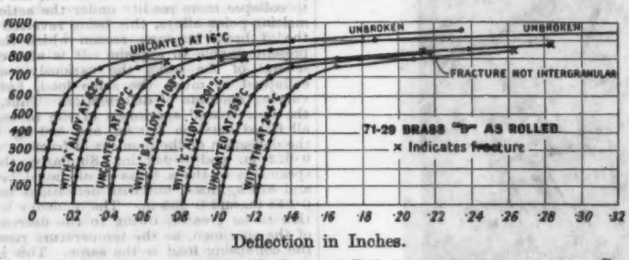

FIG. B. LOAD-STRAIN DIAGRAMS, 71:29 BRASS "D" (CONSISTS WHOLLY OF α CONSTITUENT).

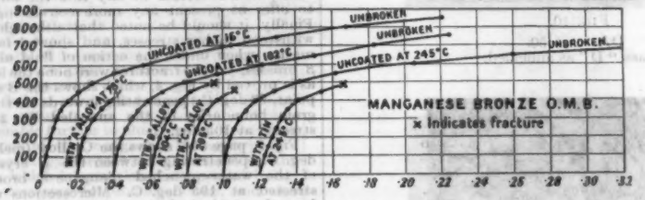

FIG. C. LOAD-STRAIN DIAGRAM, "MANGANESE BRONZE" "O.M.B." (CONTAINS BOTH α AND β CONSTITUENTS).

work where heating may occur, and where solder or other fusible alloy is present, is clearly manifest.

In conclusion, the author begs to thank Mr. W. Clark, director of Messrs. Vickers, Limited, for permission to communicate this Note; his friends, Mr. H. B. Weeks of Barrow, and Mr. H. W. Clarke of Birmingham, for the samples of "manganese bronze" and brass, respectively, and Mr. J. H. Huxley, A.R.S.M., F.I.C., for the chemical analyses. He also acknowledges with pleasure the valuable help rendered by his assistants in the Vickers Research Laboratories, and particularly that of Mr. G. E. Howarth and Mr. J. Swan, B.Met.

THE COMMERCIAL AIRSHIP—ITS OPERATION AND CONSTRUCTION.*

By Commander Sir TREVOR DAWSON, Bart., R.N.

It is important that there should be in the consideration of the future of the airship a conservative rather than an exaggerated attitude of mind. It should not be contended that airships will enter into direct competition with transport services which can be satisfactorily operated by railways and ocean liners; it is only claimed that the airship will be supplementary to, and will not in any way replace them. It is on the world ocean routes that the airship will have its greatest opportunity; particularly for direct communication between Europe and America, South Africa, India, Australia, and the East. On these long-distance routes the saving in time will be so great that no difficulty should be encountered in obtaining the relatively small proportion of the existing total traffic necessary to support a regular airship service.

Aeroplane versus Airship.—The question naturally arises as to the relative utility and the sphere of operation of the heavier-than-air and lighter-than-air craft. The fundamental characteristic of airship design is that increase of size results in greatly increased carrying capacity, radius of action, and reduced relative power for a given speed. With aeroplanes, on the other hand, there is no inherent improvement in efficiency with increase in size, and generally, apart from radical developments in methods of construction, the proportion of total lift available for useful load, and the speed and radius of action tend to decrease with increase in the size of the machine. The largest airships at present in use have a radius of 2,000 miles, carrying an economical load. The radius of action of an aeroplane carrying an economical load at present is about 300 miles, and any considerable increase in this length of non-stop flight would so reduce the proportion of useful load that can be carried as to cause very high running costs.

Aeroplanes when flying overland, can, of course, travel indefinite distances along routes provided with aerodromes at intervals of not more than 300 miles apart, at which fuel and oil supplies can be replenished, and with intermediate landing grounds suitable for emergency use in case of forced descents caused by engine failure. But for voyages necessitating non-stop flights of about 1,000 miles, the airship will be the more economical, and even the only practicable means of aerial transport. Viewing the position as a whole, it may be concluded that aeroplanes and airships will not conflict or compete, but will each be specially useful in its own sphere. In the case of the great world trunk routes, the airship will work between great central aerodromes, and aeroplanes and seaplanes will serve as feeders and distributors from these terminal stations on the Continental routes.

A great advantage of the airship is the much greater degree of comfort that can be offered to the passengers on long journeys of several days' duration, compared with the cramped accommodation on an aeroplane, where the noise of the engines and propellers is also very trying. A comparison may be made between the conditions of travelling by aeroplane and by airship, say from England to Australia. When the Vickers-Vimy made her wonderful trip from England, she had to land at 28 stations for the purpose of taking on fuel and oil. If aeroplanes were being used for taking passengers by this route, the passengers would either have to disembark and wait whilst the machine was being replenished at each of these stops, or otherwise, would have the inconvenience of having to change into a different machine on each occasion. The airship would only require to make two intermediate stops on such a voyage. Taking into account the loss of time by the aeroplane at the intermediate landings, and the possible difficulty of making equal progress by night and day, the greater flying speed of the heavier-than-air machine would probably be entirely nullified, and there would be very little difference in the total time taken for a journey with either method of transport.

Actual Experience with Passenger Airships.—The airship has not yet been used by this country for passenger or commercial purposes; the experience which enabled the Germans to develop the naval Zeppelin was gained by the constant use of airships for civil flying. The German Air Travel Company, formed in 1910, and financed and managed by the Hamburg-Amerika Steamship line, ran regular passenger excursions and town-to-town services during the years 1910 to 1914. During this period these airships made over 800 flights, carrying 17,000 passengers without a single mishap of any kind involving personal injury. One of the airships, Vittoria Luise, is known to have made 200 trips in 250 consecutive days. This company was able to make a profit, although the passenger rates were quite reasonable; but it is not known to what extent the company was subsidised by the German Government for the use of the airships for training airship crews.

The flight of the British R. 34 to New York and back within a week has demonstrated even more fully than the German passenger services the technical possibilities of the trans-oceanic passenger services by airship, as it was accomplished with an airship not specially built or fitted-out for the purpose, and much smaller than the type that would be required for commercial services on such a route. Yet the Germans were convinced of the commercial possibilities of the airship, as has been demonstrated by the fact that they built, after the armistice, in spite of the unsettled state of affairs of their country, special airships for passenger carrying, for a regular passenger and mail service between Berlin, Munich and Friedrichshafen, for Switzerland. The first of the special airships constructed for this service, named the Bodensee, made the voyage from Berlin to Friedrichshafen, carrying 30 passengers, in 4 hours, and was operated daily from June to October. During the suspension of the railway traffic in November, 1919, a daily load of over 1 ton of mails was regularly conveyed. It has recently been reported that the total receipts of the Bodensee whilst running were 1,330,000 marks, and running costs only 150,000 marks, which surely indicates that it was a profitable enterprise. The Zeppelin Company are now understood to be negotiating with American interests for the organisation of an airship service, to be operated from a base in Spain, to the United States and South America, and are now engaged on the design and preparations for building airships of 3,500,000 cub. ft. capacity for this purpose. These ships will have a speed of 80 m.p.h., with accommodation for carrying 100 passengers with an allowance of 100 lb. of baggage per head, together with 6 tons or 7 tons of

* Abstract of paper read at the Air Conference, London, Thursday, October 14, 1920.

mails. The promoters have stated that they think this service could be operated at rates very little higher than the present cost of first-class passages on ocean ships.

The Operation of Airship Services.

The Traffic Possibilities.—The speed of the large rigid airship of to-day is 60 m.p.h. to 70 m.p.h., and with probable increased efficiency of the engines, and the adoption of larger airships for greater world routes, there will be no difficulty in attaining a speed of at least 80 m.p.h., which would enable an average speed of 60 m.p.h. to be attained on long voyages without difficulty. The fastest ocean steamships of the world cross the Atlantic at a speed of 28 m.p.h.; but even this speed is exceptional, and is confined to liners of the very largest size; 18 knots is more usual. It is only between great centres of population in Europe and the United States that there is a large enough volume of passenger traffic to justify the great size of steamship necessary to maintain a speed of even 22 knots.

In the case of airships of even the largest sizes contemplated, the number of passengers and the weight of mails required to maintain a service is relatively small, and they could therefore be run over routes where an average speed of more than 18 knots (21 m.p.h.) by steamship would be commercially impossible. Even on the transatlantic route, between Europe and the United States, there must be in any week in the year some hundreds of persons to whom the crossing of the Atlantic in two or three days, instead of six or more, would be well worth the expenditure of, say, 50 per cent. more than the usual steamship fare.

There should be no difficulty in reducing the present time taken from London to Cape Town from 18 days by steamship, to 5 days by airship; to India from 16 days to 4 or 5, thus reducing the time to less than one-third of the present minimum. Postal services by airship will fill the gap between cable communication and the present mail services. A letter weighing an ounce could contain some thousands of words, and if the cost of cabling only a single word were charged for its carriage by air, the airship transport company would be handsomely remunerated.

Size of Airship Required.—From an examination of the great ocean routes of the world, it is found that a maximum distance of non-stop flight between stations of 3,500 miles will allow of direct communication between any of the great traffic centres of the world, so that an airship able to carry enough fuel and oil to fly this distance at the required speed, including a suitable reserve to provide for adverse weather, and carrying an economical load of passengers, mails, &c., would be suitable for service on any of the world routes.

It is considered that the most suitable economical commercial speed to be maintained throughout these voyages should be 60 m.p.h., which, while high enough to afford an attractive saving of time, would be economical. To enable this average to be maintained the maximum speed at full power should be at least 80 m.p.h. To conform to these requirements, and to enable an economical load to be carried after allowing for the additional weight involved in fitting passenger accommodation, a rigid airship of at least 4,000,000 cub. ft. gas capacity will be required, which would enable suitable provision to be made for carrying about 100 passengers. This size of airship would have a length of about 800 ft., with a maximum diameter of about 100 ft. The largest airship yet built is not much over 2,000,000 cub. ft., so that considerable advance has still to be made in design and construction before an airship can be produced suitable for regular and economical passenger carrying.

Safety and Durability.—The objection frequently put forward that airships run a great risk of destruction by fire is a natural impression caused by the frequency with which the German Zeppelins raiding London were found to be vulnerable to incendiary bullets. One might as well condemn merchant ocean-going ships because they could be sunk by gun fire or torpedo. Only one case is known of a rigid airship being accidently destroyed by fire. The only other risk whilst in the air is that of breakdown of the engines, and the airship being left helpless at the mercy of the wind. Rigid airships never have less than four engines, and the large passenger ships will have six, eight, or even more.

With regard to danger of passing through electrical storms, information has been published that the Bodensee actually passed through an electrical discharge without other damage than the burning of the wireless aerial. There is still room for considerable improvement in the endurance and reliability of the airship engine, and it is probable that a special type will require to be evolved to withstand the extremes of heat and cold which would be experienced in some parts of the world.

The Influence of Weather.—Winds will, of course, have a considerable effect on the time taken to complete a voyage. As is well known, there are, at sea level, between fairly well-defined latitudes, permanent winds of generally constant direction, of which advantage can be taken by suitably laying out the course to be followed and varying that according to the season. Again, at the higher levels of the atmosphere, there is, in most latitudes, a constant drift which may be helpful if the winds at other levels are unfavourable. But although fairly precise information is available about the permanent and periodic winds at sea level, very little co-ordinated work has yet been done in charting the prevailing and seasonal winds of the higher levels of the atmosphere.

If the directions of all the prevailing winds, both in the lower and upper levels, were known to airship navigators, the duration of the journey could be greatly shortened by taking advantage of them, even if this entailed deviation from the direct route. It is now the opinion of meteorologists and experienced airship pilots that, instead of wind influences having the effect of lengthening the time for voyages, the passages over long sea routes will be shortened, when routes are suitably arranged in accordance with the meteorological information regarding the prevailing winds and local conditions. On the average, about 15 m.p.h. to 30 m.p.h. may be added to the speed over the ground.

The Development of the Mooring Tower.—There is no reason why the actual departure of an airship at an aerodrome should in any way be delayed by wind, provided that the aerodrome is equipped with suitable mooring tower and landing gear. Following on the very successful experiments carried out with non-rigid airships moored to the type of mooring mast introduced by Air Commodore Masterman, an experimental mooring tower for rigid airships was developed by Vickers, Limited, in collaboration with the Air Ministry, and used at one of the air stations for a comprehensive series of mooring tests with R. 24—one of the early British rigid airships of the R. 23 Class. During these tests the ship lay out continuously for several weeks, during which it was subjected to gusts of wind blowing up to 50 m.p.h., phenomenally heavy rainfall, snow storms, and every extreme of the British weather. The behaviour of the airship demonstrated conclusively the practicability of this system of mooring, and it was found that only six men at a time were needed to look after the mooring of the ship.

Designs are now being prepared for a mooring tower specially arranged for use with passenger-carrying airships. The revolving head of the mast will be provided with a powerful winch for hauling in the mooring head of the ship to the automatic coupling apparatus and shock absorbing buffer, which will enable the airship to be coupled up without difficulty even in winds up to 70 m.p.h. to 80 m.p.h. A passenger lift will be provided within the mast structure, in which the passengers will be raised from the ground to a compartment at the top of the mast, from which they will enter the airship by means of a covered-in gangway, from which an internal corridor in the airship will communicate with the passengers' quarters.

Pipe mains for the supply of hydrogen, petrol and water to the airship also run up to the head of the tower, from which they can be readily coupled to pipes in the airship, and so enable gas, fuel and ballast to be supplied to the vessel in preparation for her next voyage with the least possible delay. When all supplies and the passengers are on board, the coupling gear can be released, and the ship is free to proceed on her voyage however strong a wind may be blowing at the time.

Airship Bases.—Eight main bases, with the same number of intermediate calling stations, would serve for airship services linking up Europe to North and South America, Egypt, South Africa, India, and Australia, and from these main bases smaller airships or aeroplanes would afford communication by air between all the chief centres of population in the world. Each of the main bases would be provided with a number of sheds and mooring towers according to the number of airships in service, and the intermediate stations with mooring towers only. Both main and intermediate bases would be provided with hydrogen generating plant and storage for petrol and oil. The wireless equipment would be such as to enable an airship *en voyage* to be in constant communication with the nearest base.

The need for Trained Pilots.—Whilst we now have in this country airships which would be suitable for the running of experimental mail-carrying services, and the designing and constructional facilities which would enable us to build the larger type of airship required for regular passenger-carrying services, we still lack experience in the flying and handling of airships under the conditions appertaining to commercial services.

A great deal of flying experience must be obtained by our airship pilots before they will be able to take an airship out at any time of the day or night and bring her up to the mooring mast in any weather conditions. The necessary experience and training can only be obtained by regular and constant flying, and it is strongly recommended that the airships that are at present available should be kept in constant service by the Air Ministry for this object. It would be desirable to put up several mooring masts of the simplest type necessary for training purposes in order that the pilots may become familiar with their use before having to undertake the command of an airship that will require to be used on the regular commercial services. The Germans have a great advantage in this respect, as many of the Zeppelin pilots who were employed on the passenger airships before the war have now made some thousands of flights.

Will the Cost be Reasonable.—Fairly reliable estimates of the running costs of airships can be made; but allowances for depreciation and maintenance, in particular, are at present a matter of surmise, as these can only be ascertained by trial on a commercial scale over a period of years, airship transport cannot be justified as a commercial proposition until an experimental service, to be referred to later, has demonstrated that these charges are within an economical limit.

An approximate estimate has been prepared of the possible limits of the cost of carriage by airship, taking, on the one hand, the most favourable conditions that might be expected with a fully established service on a favourable route with the best possible weather conditions, and such a demand that the service would be operated at full capacity all the year round; and, on the other hand, taking the most unfavourable conditions as regards cost and running conditions. The service investigated was on a basis of a regular two trips each way per week between places requiring a non-stop flight of 3,000 miles, which would be operated by airships of the 4,000,000 cub. ft. capacity type previously described.

Taking the speed as averaging 60 m.p.h. for the voyage, the time taken would be 50 hours, so that each ship could easily make two voyages per week. Thus two ships in service would make the required two trips each way per week. A third ship is held in reserve to enable each ship to be laid up periodically in turn for complete overhaul. If the two trips each way were kept up 52 weeks in the year, each of the three ships would have to do an average of between 3,400 hours and 3,500 hours flying, and on this the cost of maintenance is based.

Making an ample allowance for the weight of petrol and oil, and other non-essential loads, this size of airship would be able to carry a full load of 24 tons of passengers, mails or light freight. Accommodation is provided for 100 passengers, who would be allowed a total weight of 300 lb. per head, thus leaving further carrying capacity for about 10 tons of mails and special freight.

Without entering into details of the estimates—which are based on present-day prices—the following figures, which indicate the conclusions arrived at, may be given:—

Capital Required.

	£
For three airships and flying equipment	1,500,000
For sheds, mooring masts, and other equipment for two aerodromes ...	1,300,000
Giving a total of	2,800,000
Or, say, with working capital, a round figure of	3,000,000
Allowing for paying interest at 15 per cent. on this capital, this would mean an annual charge of	450,000

Depreciation and Obsolescence.—The probable life is variously estimated at from three to five years, so that the charge on this account for the airships would be from 300,000*l.* to 500,000*l.*, and for sheds and ground equipment, say, 100,000*l.* per annum, a total of from 400,000*l.* to 600,000*l.*

Repairs and Maintenance.—Owing to the wear and tear of constant service, it is probable that the outer covers would require replacement about every six months, and the gas bags every two years, whilst the engines—subject to regular overhaul and replacement of working parts—should have a life of at least two years. The items of repair and maintenance are estimated at from 100,000*l.* to 300,000*l.* per annum.

Establishment Expenses.—These would amount to, say, between 150,000*l.* to 200,000*l.*

Insurance.—In the absence of any accumulated statistics of risk, it is impossible to say what rates would require to be paid for insurance. In the early stages the rate will be high, and may amount to 33 per cent. per annum on the total airship value.

Running Costs.—The running costs, including petrol oil and hydrogen, can be estimated with some degree of confidence, and for airships of this size will total from 40*l.* to 60*l.* per hour's flying.

Total Annual Costs.—These would accordingly range between 1,650,000*l.* and 2,700,000*l.*

Earnings.—Assuming a full load is carried every voyage, the total paying load per year is 5,000 tons, carried a distance of 3,000 miles, and to cover the total expense enumerated, the rate would require to be from 2*s.* 3*d.* to 3*s.* 8*d.* per ton-mile. It is highly improbable, however, that, even under any circumstances, a full load would be carried on every voyage on a regular service maintained the year round, and it would be reasonable to take a load factor of only 50 per cent., which, of course, would double the above rates, which would then be from 4*s.* 6*d.* to 7*s.* 4*d.* per ton-mile. If carrying passengers and allowing for the cost of their food, attendance, &c., this would correspond to from 10*d.* to 1*s.* 4*d.* per mile, or rather more than twice the present rates for first-class passage by ocean liner. The rate for carrying mails would be from 5*d.* to 8*d.* an ounce for the 3,000 miles.

It is most important to observe that, even when carrying maximum load, the running costs or the cost of actually flying the airships only forms about 20 per cent. to 25 per cent. of the total cost of the service, the remainder being overhead cost, which continues irrespective of the amount of traffic that is handled, and would not be greatly reduced even if the ships were laid up. This is the crux of the matter, and shows quite clearly that the possibility of operating airships at an economic cost depends entirely on being able to ensure a regular and uniform traffic.

Desirability of Experiment on a Commercial Scale.—As often happens in pioneer work, a service expected to show good profits when fully established may have to face considerable losses during the initial stages, whilst building up a regular traffic and justifying by actual performance the confidence of prospective users in its reliability and safety.

Some of the existing service airships are quite suitable for adaptation to carry out experimental services over comparatively short distances, and a very suitable route for this purpose would be that from Egypt to India, *via* Basra and Karachi, where the maximum distance between bases need not be more than 1,250 miles. On this route settled weather prevails practically the whole year round, and a special opportunity is offered of showing a very considerable saving in time with even only a moderate air speed, owing to the direct route which can be taken as compared with that by sea.

Experience gained on such an experimental service as this, particularly in the carrying of mails, would enable actual figures for the cost of operating and maintenance to be obtained, and also secure valuable data regarding the effect of extreme temperature conditions on the fabric used for the airship outer covers and gas bags.

In view of the great imperial importance of airship

services, and of the value of continuing to stimulate scientific design work, and the training of pilots in operating airships for naval purposes, it is thought that such a trial of airship transport on an experimental scale should be made with the co-operation of the Imperial and Dominion Governments, either as a purely State enterprise, or in association with the great shipping companies and transport interests.

State Ownership or Private Enterprise?—Under a responsible and qualified administration the support of the State would be a great asset, particularly as the most suitable traffic for airship services, in the initial stages, would be the carrying of mails and Government traffic. State assistance and control would also be most valuable in the provision and maintenance of the great terminal bases from which the airship services would operate, even if and when the operation of the actual service is taken over by private control. But for the actual operation of the airship services private enterprise would be the best arrangement, with competition always inciting to technical improvement and economy of operation. Such a company could undertake the carrying of mails on a yearly contract with a guaranteed minimum load.

Airship Construction and Development.—The power-driven airship only became a mechanical possibility with the advent of the light internal-combustion engine, developed by automobile engineers in the latter part of the nineteenth century, and the rigid airship only became a practical problem with the invention of light and strong aluminium alloys at the beginning of the twentieth century.

The development of the rigid airship by the Zeppelin Company has been steadily prosecuted since the year 1900, and improvements in construction and performance, although slow in the earlier years, were forced ahead during the great war. Rigid airship construction in this country was only really commenced in the year 1914, and has suffered many vicissitudes owing to changes in policy; consequently progress in design and economy in rate of construction have been slower than would have been the case if there had been steady and uninterrupted development. The most serious result of this want of continuity in policy, and the frequent stoppages in construction, has been that it has not been possible to prosecute a progressive programme of research and experiment, and to offer that continuity of employment which is essential in order to build up an experienced staff and train specialised workers.

Airship design in this country, therefore, was primarily based on German practice, and it is only in the most recent designs of R. 80, by Vickers, Limited, and the R. 38, now being built by the Air Ministry, that purely British ideas have been put into practice.

With the exception of the Wolseley-built Maybach motor, no essentially-airship engine has yet been produced in this country, and although excellent results have been obtained with the use of the Rolls-Royce and Sunbeam engines for relatively short runs, an engine of a simpler and more robust type is wanted which can run continuously for periods of at least 50 hours without any risk of breakdown and without requiring constant overhaul by highly skilled labour. The ideal type of internal-combustion engine for airships would be of the Diesel two-cycle type, which would have most valuable advantages. As 1,000 brake horse-power could probably be developed in not more than eight cylinders, and all induction and exhaust valves would be eliminated, the possibilities of breakdown would be greatly reduced and overhaul would be greatly simplified. As no electric ignition apparatus would be required, the elimination of magnetos and sparking plugs would remove the most constant source of trouble in aero engines. Similarly no carburettor would be required and this would remove another source of trouble. An engine of this type could be run on almost any kind of liquid fuel. This would reduce a considerable item in the running costs and facilitate supplies at out-of-the-way stations. The heavy fuels used would also eliminate the danger of petrol fire. On the long duration flights which will be the practice with airships, the weight of fuel and oil is many times greater than the dead weight of the engines, and for this reason the lower fuel consumption would more than compensate for a considerably heavier weight of the Diesel engine.

Fifteen years ago the petrol engine weighed 12 lb. per brake horse power, and it has now been reduced to 3 lb., and in some cases even less. This reduction in weight is almost entirely due to the use of modern high tensile steels and aluminium alloys. There has not yet been any serious attempt to produce a Diesel engine suitable for aero purposes, and the lightest type of Diesel engine yet made weighs about 30 lb. per brake horse-power; but there does not appear to be any reason why a suitable Diesel engine should not be produced of, say, 10 lb. per brake horse-power.

Possibilities of Reducing the Cost of Construction and Operation.—In order to reduce the cost of operating airship services, it is desirable that consideration should be given to the possibilities of lessening the cost of construction, and also of effecting all possible improvements that would lower running costs. With increase in size it should be possible to simplify structural design, and relatively cheapen the cost of manufacture and erection.

The rigid airship only became possible by the use of the special alloy "duralumin," which has a specific gravity of only 2·8, has a tensile strength of 28 tons per square inch, or practically the same strength as mild steel for only one-third its weight. With this material the constructional design of rigid airships has been developed by mathematical analysis and experiment to a degree of efficiency far beyond that attained in any other branch of structural engineering, but finality has by no means been reached, and useful reductions in structural weight are possible by continuing systematic study of structural detail design.

Rigid airships built in this country have cost at least twice as much as those built by the Zeppelin Company, due to the fact that we have never yet been able to build them on a production scale. It is definitely known that the Zeppelin Company have built at the same works 12 or more in succession of the same type and design. This has enabled them to erect and complete a ship in 12 weeks from the date of commencement of building. We have never yet built more than two to the same design, and consequently the time for production has been about two years, with the consequence that the cost has been much greater than would have been the case if a number of airships had been built on repetition lines to the same design.

The chief items in the actual running cost of an airship in which it is possible to effect considerable savings, are the cost of fuel and of hydrogen. If, as has been previously mentioned, an engine of the Diesel or some other type that could use cheap fuels was developed, the cost of fuel used would be greatly reduced. In the case of an airship making frequent long voyages, consumption of gas is mainly due to losses whilst in flight necessary to reduce lift corresponding with the loss of fuel consumed by the engines. The losses of gas escaping by diffusion and leakage are relatively insignificant. What is more serious than the loss of gas by leakage is the deterioration of the purity of the gas owing to the admixture of air which percolates through the fabric simultaneously with the gas leakage. But an airship making long voyages regularly and discharging a considerable proportion of gas each voyage, and then refilling with fresh gas, could probably maintain a sufficient purity for a long time. It is, therefore, evident that for airships in daily service over long voyages, the question of gas tightness is not relatively of importance.

Although gas bags lined with goldbeaters' skins have extremely low permeability, the cost of the skins and the amount of labour required to apply them to the fabric is very great, making the bags very costly. These goldbeaters' skins are an animal tissue obtained from the stomach of the ox, and the number of skins used for an airship of the size of R. 34 represents over 500,000 cattle. It is therefore considered that for ordinary commercial use it would be unnecessary to have skin-lined gas bags provided hydrogen could be produced at a sufficiently low figure. At the same time low permeability is desirable, and efforts should be continued to find a substitute for goldbeaters' skin which can be cheaply applied in the form of a doped film; but the great difficulty will be to find a material that will have the necessary gas-tightness and still retain the necessary flexibility.

The cheapest method of obtaining hydrogen would be to utilise gas which is the by-product of the alkali or other industries, and where other requirements will allow of this, great economy would be obtained in hydrogen costs by locating a terminal or intermediate base near such an industry. This, however, would only be possible in very exceptional cases, and it would generally be necessary to have gas-generating plants.

Conclusion.—It is very difficult to foresee what developments in aircraft the next ten, or even the next five, years may bring; but Imperial interests demand that every endeavour should be stimulated to maintain scientific and practical developments in this country. It would be dangerous to wait and see what other nations will do.

It is significant that the United States have voted 25,000,000 dols. for airship construction, and with an eye to future developments, is building an airship shed which will hold airships of 10,000,000 cub. ft. capacity.

France, after hurriedly disposing of her airship material at a heavy loss in the interests of economy, has entirely changed her attitude, and has voted an equivalent of 3,000,000*l.* to re-equip her airship service.

Italy is a firm believer in the airship, and is making steady progress, and at her present rate, has the lead in construction of airships of the semi-rigid type.

Germany, with her unparalleled experience in airship construction, is in a position to go ahead as soon as the restrictions of the Peace Treaty allow, and but for these there is no doubt that she would already have in actual operation air liners crossing the Atlantic. A recent report from Berlin states that the Zeppelin Company is contemplating building these airship liners in the United States and so evading the prohibitions of the Allies, the scheme being to build two super-Zeppelins for use in freight and passenger service between Berlin and San Francisco, calling at Paris, New York and Chicago, the schedule time for the entire trip from Berlin to San Francisco to be less than four days. From information obtained from America it is understood that these airships are to be capable of carrying loads of 30 tons. The scheme is said to be backed by the Hamburg-America Line, and prominent American financiers. This being the case, a widespread Empire like our own should surely do all it can to build up a powerful fleet of commercial airships. We, as the leading mercantile nation, with interests all the world over, should lead in the new era of aerial transport as we have led on the sea in the past.

The Royal Aeronautical Society.—The Society has been informed by the Home Office that it is now authorised to adopt the use of the prefix "Royal" in the abbreviations for Fellows and Associate Fellows. These members will therefore be entitled to use the letters "F.R.Ae.S." and "A.F.R.Ae.S." respectively after their names.

CATALOGUES.

Electrical Fittings.—Leclanché batteries, jointing materials and fittings, and supplies for house wiring made by the British Insulated and Helsby Cables, Limited, Prescot, Lancashire, and noticed recently in this column, are described in new editions of their catalogues.

Feed-Water Measurement.—The Lea Recorder Company, Limited, 28, Deansgate, Manchester, send a leaflet catalogue of their V notch meters for measuring boiler feed water at 212 deg. F., and at higher temperatures, in a totally enclosed tank in which the flow is automatically regulated to the demands of the feed pump.

Centrifugal Pumps.—A catalogue of several series of centrifugal pumps, for moderate and low speeds, comes from Messrs. Peter Brotherhood and Co., Limited, Peterborough. These range from 2-in. to 29-in. connections. Electric motor, vertical engine or steam turbine drives are supplied as required.

Washing Machine.—The Seaforth Engineering Company, 14, Victoria-street, London, S.W. 1, send an interesting catalogue of a washing machine in which the clothes are lifted out of the water, squeezed, and then returned to the water and rinsed. The cycle of operations is clearly illustrated in the catalogue, which deserves attention from laundry owners.

Electric Switchgear.—A very complete and well-arranged catalogue of low and medium tension switchgear comes from the General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4. Switches, cut-outs and accessories for circuits up to 600 volts are divided mainly into the open and ironclad types, each of which is further subdivided. The requirements of factory, workshop, mine and house are all catered for.

Boiler-Feed Pumps.—A centrifugal turbo boiler-feed pump is described in a catalogue received from the Coppus Engineering and Equipment Company, Worcester, Mass, U.S.A. The pump has a single shaft on which both turbine and pump are fixed and the lubrication and packing are simplified to a fine degree. The four standard sizes made are suitable for work against maximum pressures of 135 lbs. to 175 lb. per sq. in.

American Machinery.—The International Purchasing Bureau, 203, East Fifteenth-street, New York, U.S.A., send a number of circulars offering to supply catalogues for a very extensive variety of tools, machine tools, engines and machinery for mills, railway material, agricultural machinery, &c. The bureau undertakes to purchase and export practically any product of the industries of the United States, but the names of the manufacturers of the various products are not mentioned.

Steam Wagon.—A very cleanly-built and powerful steam wagon made by Messrs. Robey and Co., Limited, Lincoln, is explained in full detail in a special catalogue, to hand from that firm. The wagon carries a load of 5 tons and is capable of drawing a trailer loaded with 3 tons in addition, though the makers do not advise the use of rubber-tyred wagons for tractive work. The engine is compound and is mounted over the boiler, which carries a working pressure of 200 lb. per sq. in. All the parts are separately illustrated.

Wireless Telegraphy.—Installations for small, medium and large ships are described in a catalogue issued by Siemens Brothers and Co., Limited, Caxton House, Westminster, London, S.W.1. The power required for the largest is only 4 h.p. The firm either sells the apparatus outright or supplies it for a fixed annual sum which includes the use and upkeep of the apparatus and the wages of the operator. With this arrangement the responsibility for supplying qualified men and for conforming to all legal requirements, both home and foreign, rests with Messrs. Siemens Brothers.

Steam Engines.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, send a catalogue of portable and semi-portable steam engines and boilers. The engines, which are of the single-cylinder type, are made in six sizes giving from 9 to 39 economical horse-power, but are all capable of taking much greater continuous loads and still higher momentary loads to deal with the uneven work generally required from these engines. The catalogue also shows three compound and three double-cylinder simple engines, all of which are very substantially constructed, and all are designed so as to be easily accessible for cleaning and overhauling.

The British Corporation Register.—The British Corporation for the Survey and Registry of Shipping has issued its Register of Vessels for 1920, and also a new edition of the Rules for Classification and Construction. Both works are excellently printed and conveniently arranged. A prefatory note to the Register of Vessels explains that the Committee of the Society has made arrangements with the Committees of Registro Navale Italiano, the American Bureau of Shipping, and the Imperial Japanese Marine Corporation, which provide for the mutual acceptance by the societies of the classification and survey of vessels constructed under rules and conditions which are equally effective. The organisation of the societies in Italy, the United States and Japan is thus rendered available for vessels which are classed, or are intended to be classed, with the British Corporation, while the organisation of the society in the United Kingdom is available for vessels classed, or to be classed, with the societies in the countries named. Besides the several committees, the names are given of the society's surveyors in this country, Italy, the United States, Japan, and at a number of Colonial and foreign ports.